INFLUENCE OF OPEN TRAY IMPLANT LEVEL IMPRESSION COPING DESIGNS ON THE ROTATIONAL RESISTANCE OFFERED BY THREE DIFFERENT IMPRESSION MATERIALS – AN IN VITRO STUDY

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BRANCH I

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CERTIFICATE

This is to certify that the dissertation titled "**INFLUENCE OF OPEN TRAY IMPLANT LEVEL IMPRESSION COPING DESIGNS ON THE ROTATIONAL RESISTANCE OFFERED BY THREE DIFFERENT IMPRESSION MATERIALS – AN IN VITRO STUDY** " is a bonafide record work done by **Dr. JYOTHSNA S. REDDY** under our guidance and to our satisfaction during her post graduate study period between 2010 – 2013.

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ABSTRACT

Purpose of study: The influence of open tray implant level impression coping designs on the rotational resistance offered by different impression materials for single implant impressions.

Materials and methods: A total of 90 custom trays were fabricated and used to make impressions for nine groups of ten each. Ten impressions each were made using Nobel active, Biohorizon, & MIS open tray implant level impression coping with vinylsiloxanether, polyether, and vinylpolysiloxane impression materials. Implant replicas were connected to the impression coping using a digital screw torque checker and was recorded the peak torque values indicating maximum rotational resistance. The mean values obtained were statistically analyzed using one way analysis of variance (ANOVA) and Post-hoc Tukey HSD test.

Results: Biohorizon impression coping design offered the highest rotational resistance with all the three impression materials when compared to Nobel active and MIS impression copings.

Conclusion: The rotational resistance recorded for the combination of impression copings and impression materials were above 10 N.cm except for the combination of MIS impression coping with vinylsiloxanether and vinylpolysiloxane.

Key words: Rotational resistance, vinylsiloxanether, vinylpolysiloxane, polyether, digital screw torque checker.

INTRODUCTION

The emergence and versatility of dental implants has been an extremely important innovation over few decades with a wide scope of new treatment alternatives for the rehabilitation of partially or completely edentulous situation.[19] An endosteal implant is an alloplastic material surgically inserted into a residual bony ridge primarily as a prosthodontic foundation.[38] It is important to understand all of the steps necessary to complete the treatment of partially or fully edentulous condition with dental implants. While there are differences between natural teeth and implant fixtures, conventional prosthodontic techniques and concepts are the foundation for proper implant–supported reconstruction.[19] Predictable success in implantology can be achieved by paying attention to diagnosis and treatment planning, implant surgical procedures, impression making, passive fit of the prostheses, occlusion and recall maintenance.[19]

The fit of a restoration can be considered “passive” if it does not create any static loads within the prosthetic system or in the surrounding bone tissue.[57] Passive fit is affected by various factors such as implant position, impression technique, and expansion of gypsum casts, investing and casting procedures for the fabrication of metal framework.[3,9,35] In case of misfit between implant and abutment as well as between abutment and prostheses, compressive and traction loads could be directed to the restoration, resulting in loosening of the prostheses and abutment screws, fracture of the restoration, bone micro fractures surrounding the implants and even fracture of the implant body. Such a misfit will also lead to problems with articulation of working cast, axial contouring of interproximal contacts, open margins, lack of retention and résistance to displacement. Marginal discrepancies caused by the misfit might enhance plaque accumulation, affecting soft and/or hard tissue around the implants.[1,5,25] The clinically acceptable level of discrepancy of the framework have been reported in the range of 10μm to 150μm based on various clinical studies.[31,35,50] Even though implant components and bone appear to tolerate certain degree of misfit without biomechanical problems, it is appropriate to optimize their fit by ensuring accurate reproduction of the inter implant relationship in the working cast for the fabrication of passively fitting framework.[31]

An accurate impression is mandatory to ensure acceptable fit of an implant–supported prosthesis.[34,43] The accuracy of impression is influenced by various factors such as depth and angulation of implants, position of implants, impression material, impression technique, type of impression trays, different connection level (implant or abutment level), design of impression copings, splinting or non-splinting transfer copings, time delay for impression pouring.[17,33,34] Several impression techniques have been advocated in the literature for implant/abutment level impressions include the indirect technique (closed tray) and direct (open tray) techniques to ensure the passive fit of the prosthesis.[13,34,49]

Implant level indirect transfer for closed tray impression technique involves tapered impression copings[12,49,61] which would be repositioned along with the replicas within the impression. The advantage of this technique is that the implant replicas are visually fastened to the impression copings and therefore ensuring its complete seating.[14,34,49] But on other hand the reseating of the coping in the elastic impression may not be accurate, which can reflect an error in the inter implant relationship in a vertical axis.[2,13] The instances of impression material being distorted or damaged is also possible while using closed tray impression technique in multiple implant situations, especially if implants are not parallel to each other.[2,23]

In order to overcome the deficiencies associated with the closed tray impression technique, the open tray implant level impression technique have been introduced for single as well as multiple implant situations. This open tray impression uses square copings [13,46,60] and an open tray (a tray with an opening) allowing the head of the impression coping screw to be exposed. Before removal of the tray, after the impression material is set, the coping screws are unscrewed, open tray impression copings are picked up along with the impression. The implant replicas are connected to the copings inside the impression to fabricate the definitive cast. The advantage is that, the coping remains within the impression and so there need not be any concern for replacing it into its respective space.[14,34,49] Also, the concern of angulated implants deforming the impression material upon removable of impression does not arise. The limitation includes blind fastening of the analog that can result in rotation of the impression coping within the impression.[17, 49, 56]

Splinting of open tray impression copings has been suggested by many authors in order to maintain the accurate inter implant relationship, when compared to that obtained with non-splinted impression copings.[35,49,61] However splinting of the open tray impression coping is technically not possible with single implant situation or randomly distributed single implant situation in a partially edentulous arch. The rotation of impression copings within such open tray impression will likely influence the passive fit of abutment /prosthesis, contact points with the adjacent teeth and occlusion. The rotational tendency of the open tray impression copings while connecting the analogs is influenced by the rigidity of the impression material and the design of the impression coping.[52,56,61]

The impression materials used for making open tray impressions should possess sufficient rigidity to prevent accidental rotation of the coping and exhibit minimal positional distortion.[61] Various impression materials are recommended for making implant impressions which will include polyether and addition silicone.[35,49,56] Polyether has been suggested for completely edentulous multiple-implant situations due to its excellent resistance to permanent deformation, low strain under compression and high tear resistance.[61] The use of polyether impression material for a partially edentulous situation presents a difficulty of retrieving the set impressions intraorally because of its high rigidity.[14] Addition silicone with its more favourable modulus of elasticity allows easy removal of the set impression in such situations.[17,56,61] The torque values to resist the rotation of impression copings for addition silicone are reported to be lesser than that of polyether.[33,36,61]

A newly formulated elastomeric impression material vinylsiloxanether has been introduced recently in order to encompass the desirable properties of vinylpolysiloxane and polyether materials for making implant impressions. According to the information provided by the manufacturer, the combination of vinylpolysiloxane and polyether components provides theoretical advantages of maintaining elastic properties of vinylpolysiloxane and hydrophilic and rigid properties of polyether while achieving its final hardness. One clinical study has been reported comparing the efficiency of vinylsiloxanether with polyether material and the assessment of it proved to be equivalent or superior to that of polyether.[16] However, laboratory studies evaluating its physical properties and accuracy for making implant impressions have not been reported till date.

The design of the open tray impression coping itself can influence the rotational tendency within the impressions while connecting to the implant replicas. Wee compared the amount of torque required to rotate a square impression coping in an impression.[61] Though the importance of impression copings design has been mentioned, its influence on resistance to rotation has not been reported. The combined influence of resistance offered by an elastic impression material and the design feature of the open tray impression coping has not been studied.

Digital screw torque checker has been used in various studies to evaluate the reverse torque values to determine the screw loosening of abutments/prosthesis. The device has the capacity to measure and store the readings. It has an accuracy level of 0.05 N.cm, which helps to detect small change in torque values and has an inbuilt memory to store up to 100 readings. A similar torque measuring device was used to assess the torque values to rotate the open tray copings in one report.[16] This instrument can be successfully adopted to analyse the rotational resistance offered by different impression materials for open tray impressions. In view of the above, there is a need to identify the best combination of open tray impression coping design and impression material to overcome the problem of rotation of unsplinted impression copings within the impression material.

Hence, this in-vitro study was aimed to comparatively evaluate the influence of implant level open tray impression coping designs on the rotational resistance offered by three different impression materials. Also added to the aim of the study are the following objectives,

1. To evaluate the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Nobel active open tray implant level impression copings.
2. To evaluate the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Biohorizon open tray implant level impression copings.

3. To evaluate the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with MIS open tray implant level impression copings.
4. To compare the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Nobel active open tray implant level impression copings.
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7. To compare the rotational resistance offered by vinylsiloxanether impression material with Nobel active, Biohorizon, and MIS open tray implant level impression copings.
8. To compare the rotational resistance offered by polyether impression material with Nobel active, Biohorizon, and MIS open tray implant level impression copings.
9. To compare the rotational resistance offered by vinylpolysiloxane impression material with Nobel active, Biohorizon, and MIS open tray implant level impression copings.

REVIEW OF LITERATURE

Fehling AW et al (1958)[18] Autopolymerising acrylic resins have been used for the fabrication of custom trays, but concerns about the exposure of dental personnel to acrylic resin monomer have been expressed. Distortion from polymerization shrinkage and residual stress relaxation makes them a less than ideal material for custom trays .Research has been suggested that custom trays should be fabricated at least 24 hours before impressions are made, although some investigators have suggested different periods (20 minutes to 9 hours) between making resin trays and using them, to allow the material to become relatively dimensionally stable. Autopolymerising resin continues to shrink, with significant dimensional change occurring up to 180 days.

Reisbick et al (1973)[44] once elasticity is developed; seating of the impression may induce elastic strain, which upon release would result in a distorted or inaccurate impression. Some of these strains would be released immediately and others would be released during storage of the impression before pouring the cast. Viscosity values of impression materials are most significant during the working time stage, if the viscosity is too low, the material will either run out of the tray or will not keep intimate contact with the impression site. If the viscosity is too high at the time of placement, it might not record fine details.

Eames WB et al (1979)[15] evaluated the effect of an impression material on the accuracy of the impression. A stainless steel die was made and impressions were made using polyether and polysulfide with custom trays. The trays were divided into three groups based on the spacer thickness. Group 1 had 2mm thick spacer; group 2 had 4mm thick spacer while group 3 had 6mm thick spacer. Impressions were made and casts were poured. Wax patterns and castings were made on the master die and the stone model. The results showed that the most accurate impressions were obtained using a 2mm space tray for all the materials tested.

Sneed et al (1983)[53] investigated the tear strength of polysulfide, condensation silicone, PE, and PVS by this modified simple extension tear test. The specimens were extended in a universal testing machine to test the tear strength. They found that the tear strength of PE was higher than that of the addition or condensation silicones.

Valderhaug J et al (1984)[58] evaluated the dimensional stability of elastomeric impression materials in stock and custom trays. Two metallic models of upper jaw with standardized abutment in canine and first molar region were used. Acrylic special trays 3mm thick with a spacer thickness of 2-4mm were used. Non perforated chromium-plated brass trays were used as stock trays. The elastomeric impression materials used were impregum, xantopren light body and medium body. Impressions were made and the measurements were performed immediately after removing the model from the impression, and after 1 and 24 hours, using a Nikon profile projector in the horizontal plane only. The results showed that all the measurements except one compiled with the requirements for dimensional stability of rubber impression materials in the ADA specification no.19.

Pratton and Craig (1989)[47] studied the wettability of a hydrophilic PVS material. They compared the wettability of hydrophilic PVS with PE, polysulfide, and hydrophobic PVS by measuring the contact angle of a saturated aqueous solution of CaSO4 on the impression materials with a telescopic goniometer. The wettability of the hydrophilic PVS impression material in this study was found to be not significantly different from that of a polyether impression material and both were the best among the experimental groups.

Spector MR et al (1990)[57] determined the accuracy of three different impression techniques. Three impression methods were used-i) transfer coping united with autopolymerizing resin and dental floss, impression made with polysulfide , ii)polyvinyl siloxane impression was made in a stock tray over a hydrocolloid transfer copings, iii) condensation silicone impression was made in a stock tray over hydrocolloid transfer copings. Results showed measurable distortions occurred in all three techniques and it demonstrated the potential for distortion with the transfer technique used.

Humphries et al (1990)[24] concluded that a technique with tapered copings is better than one using unsplinted square or splinted squared copings. In contrast, some studies concluded that a technique with squared copings is better than one with tapered copings. Others concluded that both techniques are equally accurate.

Carr AB et al (1991)[7] conducted a study to compare the impression accuracy using direct and indirect transfer technique. A gypsum edentulous cast with five implant abutments in the anterior mandible was used as an experimental model. 1.57mm stainless steel spheres were embedded buccal and lingual to the 1, 3, 5 implants. Tapered impression copings were used for indirect transfer technique and square copings for direct transfer technique were made, a window was cut open on top of the tray to allow access for the transfer copings for making impressions by direct technique. Polyether was used for making all the impressions. The abutment analogues and the steel spheres were positioned and the casts were poured using die stone. An accurate fitting cast framework was conducted on the master model with the steel spheres on the framework and the spheres on the model were calculated using a machinist's traveling microscope. The results showed that the direct transfer technique provided the most accurate casts.

Chai et al (1991)[10] studied the tear energy of elastomeric impression materials and the tear energy was calculated from the results of a standard trouser tear on 10 specimens of each impression material. The result showed that the tear energy of PE was higher than PVS, which was consistent with the result of tear strength study

Carr AB et al (1992)[8] compared the accuracy between direct and indirect transfer coping impression technique for a 15 degree divergent mandibular posterior two implant model in this study. A partially edentulous mandibular cast made of gypsum with two implant analogues 11 mm apart was used in the study. Stainless steel spheres were positioned buccal and lingual to the abutment cast. Custom trays with the 2mm space around the teeth and implant copings were fabricated. Polyether impressions were made. In the impression, abutment analogues and stainless steel spheres were placed and casts were poured with die stone. A n accurate fitting cast framework was constructed on the master model with steel spheres superior to implants 1, 3, 5. The vertical distance between the cast spheres on the framework and the spheres on the model was calculated using a machinist's traveling microscope. The results showed that the direct transfer technique provided the most accurate casts.

Chee WW Donovan et al (1992)[11] reviewed the properties and the techniques of impression making using polyvinylsiloxane impression materials. The accuracy of the impression material was surpassed and they can record the fine detail. They have the best elastic recovery of all available impression materials. Polymerized material is rigid but it is nowhere comparable to that of polyether. Modified with the addition of certain non-ionic surfactants they are described as hydrophilic which is a misnomer. With addition of small amounts of palladium the emission of H2 gas is prevented allowing immediate pouring of impressions also. They can get contaminated by the free sulphur present in latex gloves. They are the most accurate when used with a uniform bulk of 1.5 to 2.5 and with custom resin trays made 24 hours before impression making. The best method of impression making is to make a putty impression of the spaced cast with a stock tray and then use it for wash impression. Selective relieving of the putty or using polyethylene sheets will not give even bulk of wash material. Simultaneous technique was reported as the worst method as there would be no control of bulk and the putty would displace the wash on the prepared surfaces. Also the setting distortion of putty is included in the overall distortion of the impression.

Hung SH et al (1992)[26] compared the accuracy of one-step putty wash with two-step wash impression technique. A stainless steel model containing two full-crown abutment preparations was used as the positive control. Impressions were made with different materials and the accuracy assessed by measuring six dimensions on stone dies poured from impressions of the master model. The results showed that the inter abutment distance increased far almost all materials compared to stainless steel model. The accuracy of the addition silicone impression materials tested was affected more by the material than by technique. The accuracy of the putty was one-step technique was not different from that of the putty wash two-step technique expect at one of the six dimensions where one-step was more accurate than two-step.

Hsu C et al (1993)[23] performed this study to compare the influence of four implant transfer techniques and two master cast methods on the accuracy of abutment position. Groups were i) nonsplinted copings ii)copings secured with dental floss and Dura lay resin iii) copings secured with orthodontic wire and Dura lay resin, iv)copings secured by prefabricated resin block with .The master cast methods were i)solid cast and ii) Zeiser system. Impressions were made with polyether (Impregum f) material. The results showed that i) the Dura lay resin used for splinting is insignificant ii) there is no significant difference between splinted and unsplinted implant copings and iii) with the Zeiser system, it was possible to get reduced inter abutment error.

Goheen KL et al (1994)[20] evaluated the ability of practitioners to impart a desired torque using handheld screwdrivers and to examine the torque output of mechanical torque devices. Five surgeons and eleven prosthodontics were asked to place a 10, 20, and 32 N.cm torque on the appropriate implant component using Branemark handheld screwdrivers. Latex gloves were worn to simulate clinical situation. Also, one investigator evaluated the Branemark torque drivers, Accu-torque wrench and Implant innovations torque driver for their torque output. The results showed that handheld screwdrivers produced lesser torque values that were within the tolerances specified by the respective manufacturers. It is mandatory to use calibrated torqueing devices if proper torqueing procedures are to be accomplished.

Moseley et al (1994)[40] Tests of light-polymerized resins have indicated that these tray materials largely eliminate the disadvantages associated with autopolymerising resins by improving stiffness, form and volume stability and by reducing sensitivity to moisture. In addition the material is easy to use and saves time, because the light-polymerized resin custom tray can be used immediately after fabrication.

Millar (1998)[39] studied the relationship between viscosities and detail reproduction of elastomeric impression materials. They found that when various viscosities of impression materials were compared, the detail reproduction was different from material to material and batch to batch. Both PVSs and PEs can be manufactured with low viscosity to encourage detail reproduction but it has been shown that there is a significant difference in rheological properties of these materials during the period shortly after mixing.

Vigolo P et al (2000)[59] compared the master cast accuracy for single tooth implant replacement when non-modified and modified impression copings were used. A polymeric resin model with an implant in the maxillary arch positioned in the right second premolar was used in the study. The first molar distal to the implant and the first premolar mesial to the implant was cut bucco-palataly using a diamond disc. The angle between the molar place and the distopalatal side of the implant (MIA), premolar plane and the mesio palatal side of the implant (PIA) was measures using a Nikon profile projector. Forty identical 2mm thick custom trays were fabricated and polyether was used for impression making. In group A, non-modified square impression copings were used. In group B, square impression copings were sandblasted with 50µm aluminium oxide and coated with impregum adhesive. Master casts were fabricated with the type IV stone and the angles MIA and PIA were measured using profile projector in the master cast. The results showed that modified impression copings had a significantly lesser amount of rotational movement than unmodified impression technique.

Wee AG et al (2000)[61] compared the amount of torque to rotate a square impression coping in an impression and evaluated the accuracy of solid implant casts fabricated from different impression materials. Polyether, addition silicone and polysulfide were made using each material. A computer driver device was used to measure the torque to rotate the coping in the impression. A travelling microscope with internal light was used to measure the inter implant distance in 3 dimensional axes. The results showed that the highest torque values were obtained for polyether which was contributed to the rigidity of the material. Polyether and addition silicone gave more accurate casts than polysulfides.

Daoudi et al (2001)[14]compared the closed tray technique at the implant level with the open tray technique at the abutment level for single tooth implants and found the open tray technique to be superior and more predictable. The closed tray had discrepancies in axial rotation and inclination of the analogs.

Burns J et al (2003)[6] performed an in vitro study to study whether custom trays produce more consistently accurate implant fixture level impressions than stock trays, by use of an open tray technique. The results showed that rigid custom trays (close fit and spaced) produced significantly more accurate impressions than flexible stock polycarbonate trays.

Johnson et al (2003)[29] studied the effect of moisture on the detail reproduction of PE and hydrophilic PVS by assessing the roughness of the impression. The impressions were made of a surface analyzer calibration standard possessing a uniform saw-tooth pattern. The surface of each impression was scanned by a Surfanalyzer 4000. The result demonstrated that the PE showed better detail reproduction than PVS even though moisture led to less detail reproduction in both materials.

Lu Huan et al (2004)[36] compared tear energy (J/m2) and elastic recovery (%) for two addition silicone impression materials and a polyether material following Webber and Ryge‘s method and ASTM D412 (Test Method A), respectively. The data demonstrated that PE impression materials had higher tear energy in compression and lower elastic recovery compared to new hydrophilic addition silicone materials. Heavy-body materials had higher tear properties than light-body materials.

Nicholas E et al (2004)[42] described a two stage impression technique using an elastomeric material and impression plaster for implant impression for either completely or partially edentulous patients. In this technique, an impression was made with addition silicone using a stock tray. At this stage, the prosthetic abutments were covered with healing caps. A window was created in the tray by removing silicone around implant area the top of impression tray. Impression copings were then screwed and the impression reseated. Plaster was injected around the copings through the opening leaving the screw heads uncovered. The impression posts were picked up and the casts were poured. This technique combines the flexibility of the elastomeric impression material for capturing the impression plaster to improve the accuracy of fit of the prosthetic components.

Windhorn RJ et al (2006)[63] described an open tray technique for impression implants that is inexpensive, clean and easy to perform with materials commonly found in restorative dental practice. In this technique, a custom acrylic resin tray was fabricated with an opening in the area where the implants were located. Impression posts were screwed on to the implants. A section of boxing wax was adapted over the openings in the tray and sealed to the tray. Light body addition silicone was injected around the impression posts wile medium or heavy body VPS material was filled in the tray. In the area of wax alone, Blu_mousse Classic was added in the tray and the impression made. The excess wax and impression material over the guide pin was removed. The author prefers Blu- Mousse around the impression copings because of its rigidity.

Lee et al (2008)[34] reported that putty and light-body combination VPS impression material was more accurate than medium-body polyether impression material, when the implant was placed deep subgingivally.

Walker et al (2008)[60] evaluated and compared the detail reproduction of two hydrophilic PVS and two PE impression materials when applied under dry and moist conditions (using a uniformly applied fine mist of water). The PE showed better surface detail than the hydrophilic PVS even though adverse effects were found with both impression materials under moist conditions.

Lee H et al (2008)[33] investigated the accuracy of published implant impression techniques and examined the clinical factors affecting implant impression accuracy. The results of his investigation showed that greater accuracy was in splinted technique than with the non-splint technique and in studies with 4 or more implants, open tray technique showed more accuracy than closed tray technique.

Wenz et al (2008)[62] investigated different mixing methods of the impression materials .According to the study, the 2- step VPS method involves making the first impression using putty only, to create space inside of the impression. Subsequently, the impression is filled with light-body impression material, and then second impression is made. The 1-step method uses both putty and light-body VPS simultaneously. Results indicated that the 2-step VPS impression was significantly less accurate than the 1-step putty and light-body VPS combination impression, the medium–body VPS monophase impression, and the medium-body polyether monophase impression. Polyvinylsiloxane material may hypothetically reduce the permanent deformation of impression material determined by the stress between the material and impression copings created when an impression with the copings is removed from internal connection implants.

Lee YJ et al (2009)[33] compared the accuracy of four implant level impression techniques for angulated implants. Four groups were included: a) octagonal transfer impression coping b) non octagonal transfer impression coping c) non-octagonal pick up impression coping d) non-octagonal pick up impression coping splinted with acrylic resin. Results showed that casts produced from non-octagonal impression techniques were more accurate than those produced by other impression techniques.

Hariharan R et al (2010)[21] evaluated the accuracy of casts obtained from non-splinted and splinted impression techniques employing various splinting materials for multiple implants. Impressions were divided into four groups: a) non-splinted technique b) acrylic resin splinted technique c) bite registration addition silicone d) bite registration polyether splinted technique and accuracy was measured using CMM. Results showed that polyether bite registration silicone showed more accuracy.

Mostafa TNM et al (2010)[41] evaluated the precision of three transfer techniques using two impression materials. This study compared the accuracy between direct technique splinted and unsplinted and indirect technique with two impression materials namely polyether and polyvinylsiloxane. A travelling microscope was used to make six measurements for each cast. Results showed that there was no statistical significance difference between the impression materials regarding the accuracy.

Stober Thomas et al (2010)[55] Vinylsiloxanether monophase impressions and Vinylsiloxanether dual-viscosity impressions display acceptable accuracy for clinical use with immersion disinfection, since the results for Vinylsiloxanether were comparable to the results for representative polyether and Vinylpolysiloxane materials.

Kwon JH et al (2011)[32] evaluated and compared the three dimensional accuracy of master casts obtained with and without impression copings. Groups involved were I) impressions using open tray copings II) impressions obtained without using impression copings. The accuracy was measured using CMM. Results showed that casts obtained using open tray impression copings was more accurate than casts obtained without using impression copings.

Jang HK et al (2011)[28] determined the accuracy of implant level impressions for angled implants. Five groups were created according to the angle of divergence (0, 5, 10, 15 and 20 degrees). The divergent angle in each study model was verified with the profilometer. The results showed that the implants with 15 degree divergences was accurate and concluded that the inaccuracy of impression increases with increase in the angle of divergence.

Enkling Norbert et al (2012)[16] In 2009 the Kettenbach company launched a new impression material called Vinylsiloxanether “Identium” into dental markets .It is a chemical combination of a polyether material and a polyvinylsiloxane that is A-silicone. According to information provided by the Kettenbach company the combination of polyether material with polyvinylsiloxane components introduces theoretical advantages , given that it does maintain similar mechanical and hydrophilic properties while achieving its final hardness more expeditiously .Moreover it is possible to create a chemical bond between Vinylsiloxanether and polyvinylsiloxane.

MATERIALS AND METHODS

This in vitro study was aimed to evaluate the influence of open tray implant level impression coping designs on the rotational resistance offered by three different impression materials.

The open tray implant level impressions were made with Nobel active, Biohorizon, and MIS impression copings using vinylsiloxanether, polyether, and vinylpolysiloxane impression materials.

The following materials and equipments were used for the study,

MATERIALS:

1. Clear autopolymerizing acrylic resin (RR Cold Cure, DPI, India) (Fig.1)
2. Implant Replica (Nobel Active Internal RP; REF 34244, Nobel Biocare AB, Goteborg, Sweden) (Fig.2)
3. Implant Replica (Internal 4.5 Implant analog, Biohorizon, Birmingham, USA) (Fig.3)
4. Implant Replica (Implant analog internal hex, REF MD-RSM10, MIS Implant technologies, ISRAEL) (Fig.4)
5. Spirit level indicator (Fig.5)
6. Light cure resin sheet (Delta, Vijai Dental Depot, INDIA) (Fig.6)
7. Impression coping open tray (Conical connection RP, REF 36263, Nobel Biocare AB, Goteborg, Sweden) (Fig.7a,b)

8. Impression coping open tray (Internal 4.5 regular direct pick-up coping hexed, REF. PGRDC, Biohorizon, Birmingham, USA) (Fig.8a,b)
9. Impression coping open tray (open tray internal hex, REF MD-I0375, MIS Implant technologies, ISRAEL) (Fig 9a,b)
10. Screw driver (Manual Unigrip; Nobel Biocare AB, Goteborg, Sweden) (Fig.10)
11. Screw driver (Biohorizon, Birmingham, USA) (Fig.11)
12. Screw driver (MIS Implant technologies, ISRAEL) (Fig.12)
13. Vinylsiloxanether impression material (Identium; Kettenbach GmbH, Eschenburg, Germany) (Fig.13)
14. Vinylsiloxanether tray Adhesive (Identium; Kettenbach GmbH, Eschenburg, Germany) (Fig.14)
15. Polyether Impression Material (Impregum Penta; 3M ESPE, U.S.A.) (Fig.15)
16. Polyether tray adhesive (3M ESPE, U.S.A.) (Fig.16)
17. Vinylpolysiloxane impression material Putty consistency (Express XT Penta Putty, 3M ESPE, Germany)(Fig 17)
18. Vinylpolysiloxane tray adhesive (3M ESPE, Germany) (Fig.18)
19. Vinylpolysiloxane Light Body (Light body Express XT, 3M ESPE, Germany) (Fig.19)
20. Auto mixing gun (Dispensing Gun, Heraeus Kulzer, Dormagen, Switzerland) (Fig.20)

21. Auto mixing spiral for vinylsiloxanether (Identium; Kettenbach GmbH, Eschenburg, Germany) (Fig.21)

22. Auto mixing spiral for polyether and vinylpolysiloxane (3M ESPE, U.S.A.) (Fig.22)

23. Auto mixing spiral with intraoral tip for light body vinylpolysiloxane (3M ESPE, U.S.A.) (Fig.23)

24. Penta syringe for vinylsiloxanether and polyether material (Fig. 24)

25. Epoxy compound (M-seal ,Pidilite industries Ltd. India) (Fig.25)

EQUIPMENTS:

1. Dental surveyor (Saeshin Precision Ind. Co., Korea) (Fig.26)
2. Light cure unit (Delta, Vijai Dental Depot, India) (Fig.27)
3. Pentamix auto mixing unit (3M ESPE, Seinfeld, Germany) (Fig.28)
4. Digital Screw Torque Checker (Digital Torque Driver Model STC, Tohnichi Mfg. Co, Ltd, Tokyo, JAPAN) (Fig.29)

Description of Pentamix automatic mixing unit:

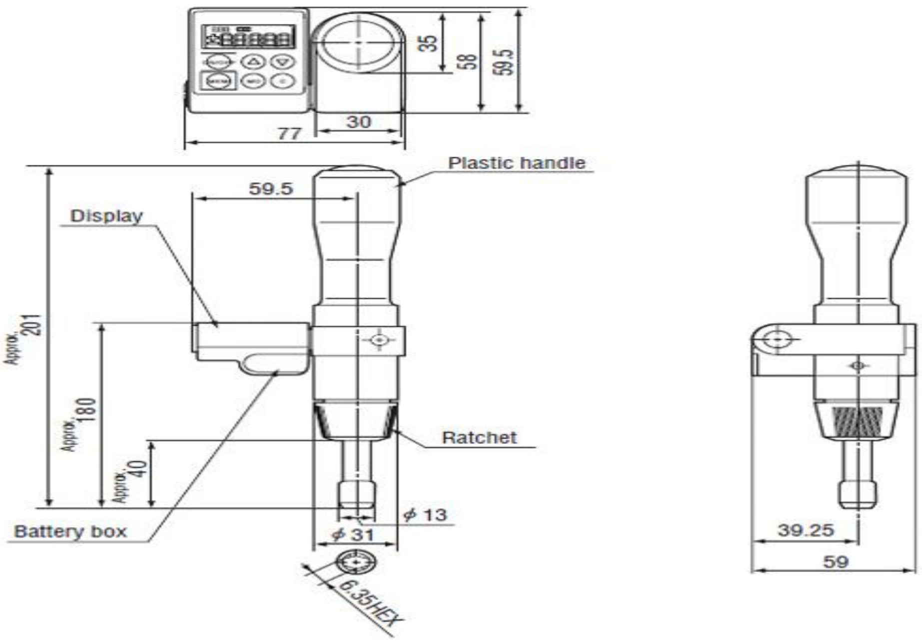
The Pentamix automatic mixing unit (3M AG, Seinfeld, Germany) (Fig.28) was used in the present study to obtain a homogenous mix of medium viscosity vinylpolysiloxanether, polyether, vinylpolysiloxane (putty consistency) impression materials. The Pentamix automatic Mixing Unit essentially consists of three components namely: Drive unit with motors, clutch and gears, Dispensing unit consisting of chain, cross-member, double plunger and piston discs and Superstructure with frame, side sections made of die-cast aluminium and polycarbonate housing. The clutch is a particularly important component. It is responsible for transmitting the enormously high torque levels, while at the same time acting as an overload safety device. It must disengage the drive unit reliably from the dispensing unit when the material in the foil bag has been used up. The clutch also provides defined, delayed disengaging each time dispensing finishes in order to prevent the pastes from dripping.

Digital Screw Torque Checker (Model STC 50CN. Tohnichi Corporation, Japan) (Fig.29)

Digital screw torque checker used in this study has capacity to measure 0.5 to 50 N.cm, with accuracy level of 0.05 N.cm, which helps to detect even minute changes in torque values. It has peak/run mode and built – in memory that can store up to 100 readings. The peak value of one particular sample can be displayed for 0.5-5.0 seconds. The torque can be applied by moving the ratchet change over knob to the position in the middle of the ‘R’ and ‘L’. Screw drivers can be attached to the screw torque checker adapter. It has a digital unit display which has following features; measurement display, unit display, auto memory display, memory key, counter value display, and mode key.

Common specifications:

Data memory	100 data
Arithmetic function	Sampling, maximum, minimum, means
Measurement mode	Peak/run
Data output	Infrared ray
Reset function	Manual/auto 0.5-5.0 sec. Adjustable by 0.5 step.
Other function	Auto power off (after 3 min.)Battery check
Power source	2xaaa alkaline battery
Continuous use (h)	16
Operating conditions(c)	Temperature 0-40, humidity below 85% RH



METHODOLOGY:

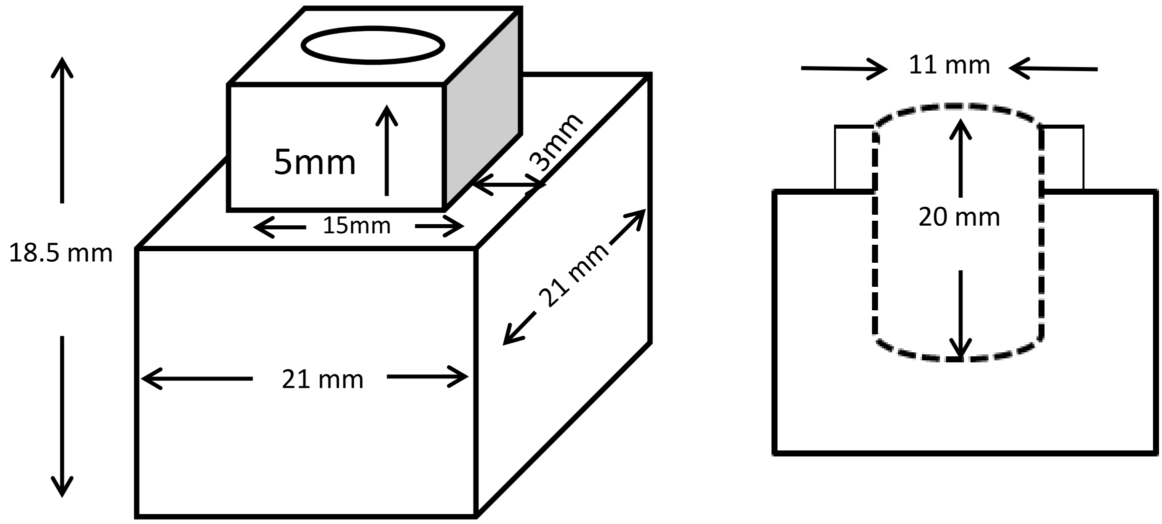
The methodology of study is divided into following stages:

I. Fabrication of master model
   a. Preparation of stainless steel blocks
   b. Placement of the implant replica in the stainless steel block
II. Custom tray fabrication
   a. Preparation of stainless steel block for custom tray fabrication
   b. Fabrication of custom tray
III. Open tray implant level impressions
   a. Impressions with vinylsiloxanether impression material with three different impression copings
   b. Impressions with polyether impression material with three different impression copings
   c. Impressions with vinylpolysiloxane impression material with three different impression copings
IV. Grouping of impressions (Test samples)
V. Evaluation of rotational resistance
   a. Connecting the implant replica to the impression coping
   b. Evaluation of rotational resistance with digital screw torque checker

I. **Fabrication of master models (Fig. 30-33)**

a. Preparation of stainless steel block (Fig.30)

Three metal blocks of dimensions 21mm X 21mm X 18.5mm with a cylindrical mould space diameter of 11mm and depth of 20mm were made. A step design was made on the periphery of the mould with a dimension of 3mm X 5mm to orient the custom tray.



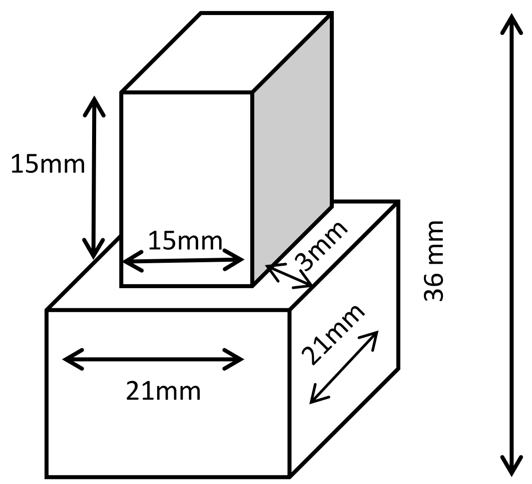
b. Placement of the implant replicas into the stainless steel block (Fig.31-33)

The custom made stainless steel block was placed in surveying platform with the mould space facing up and stabilized (Fig.31). The surveying platform of a dental surveyor (Saeshin Precision Ind. Co., Korea) was parallel to the floor using spirit level indicators. Implant replica was positioned in the center of the mould space of the stainless steel block so that the interface of implant replica was at the level of the stainless steel block (Fig.32). Autopolymerizing clear acrylic resin (Cold Cure, DPI, India) was poured into mould space and the resin was allowed to polymerize to obtain the master model. This procedure was repeated for all the three different systems of implant replica (Nobel active 4.3mm diameter, Biohorizon 4.5mm diameter, MIS 3.75mm diameter) to obtain three master models (Fig.33).

II. Custom tray fabrication

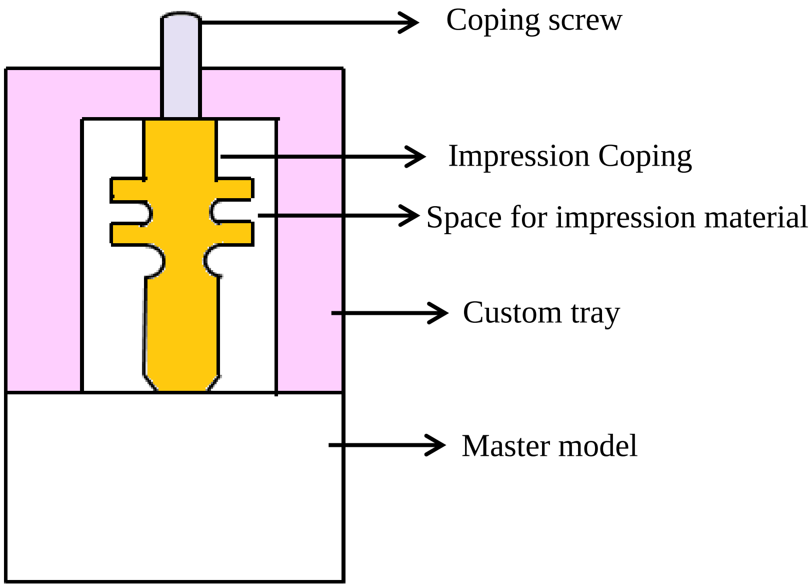
a. Preparation of stainless steel block for custom tray fabrication (Fig. 34)

A stainless steel block was fabricated with dimensions of 21mm X 21mm X 36 mm to standardize the spacer thickness of 5mm for custom tray fabrication. A step design was made on the periphery of the block by 3mm X 21mm to orient the custom tray. This was used for the fabrication of all the custom trays used in this study.



b. Fabrication of custom tray (Fig.35-37)

A 3mm thickness, light polymerizing resin sheet was adapted on to the stainless steel model (Fig.35). Later, it was placed inside the light curing unit for 6 minutes and light cured. The tray was removed from the model and kept inside the curing unit for another 6 minutes. A round opening was made on the occlusal surface of the custom tray to gain access to the impression coping screws (Fig.36). The finished tray was placed on the master model to verify its proper orientation. In this manner, 90 custom trays were made for open tray impressions (Fig.37). All the trays were left undisturbed for 24 hours, for the trays to become dimensionally stable prior to impression making. The trays were used to make open tray implant level impressions with three different open tray impression copings using three impression materials.



III. Open tray implant level impressions (Fig.38-40)

a. Impressions with vinylsiloxanether impression material with three different impression copings (Fig.38)

The open tray implant level impression copings (Nobel active, Biohorizon and MIS) were connected to the respective master model with the screw drivers (Fig.38a). The custom tray was coated with uniform layer of vinylsiloxanether tray adhesive (Identium adhesive, Kettenbach GmbH, Germany) and allowed to dry for five minutes as per the manufacturers' recommendation (Fig.38b). Medium body vinylsiloxanether (Identium; Kettenbach GmbH, Eschenburg, Germany) was machine mixed (Pentamix 2, 3M ESPE, Seinfeld, Germany) and loaded into the custom tray (Fig.38c) keeping the tip immersed in the material all the time. It was also syringed around the impression coping by another operator using the Pentasyringe (Fig.38d). The tray was then positioned onto the master model immediately (Fig.38e). The excess material that had flown over the top of the coping screw was removed to expose the coping screw through the window in the impression. The impression was allowed to set undisturbed for 5 minutes 30 seconds as per the manufacturers' recommendation. After ensuring the complete set of impression material, the coping screw was unscrewed and the impression was retrieved from the master model (Fig.38f). A total of thirty open tray implant level impressions were made on three different coping designs of ten each (n=10) using vinylsiloxanether impression material.

b. Impressions with polyether impression material with three different impression copings (Fig.39)

The open tray implant level impression copings (Nobel active, Biohorizon, and MIS) connected to the respective master models with the help of their screw drivers (Fig.39a).The custom tray was coated with uniform layer of polyether tray adhesive (Impregum Penta; 3M ESPE, U.S.A.) and allowed to dry for fifteen minutes as per the manufacturers' recommendation (Fig:39b). Medium body polyether (Impregum Penta; 3M ESPE, U.S.A.) was machine mixed (Pentamix 2, 3M ESPE, Seinfeld, Germany) and loaded into the custom tray (Fig.39c) keeping the tip immersed in the material all the time. It was also syringed around the impression coping by another operator using the Pentasyringe (Fig.39d). The tray was then positioned onto the master model immediately (Fig.39e). The excess material that had flown over the top of the coping screw was removed to expose the coping screw through the window in the custom tray. The impression was allowed to set undisturbed for 6 minutes as per the manufacturers' recommendation. After ensuring the complete set of impression material, the coping screw of the impression coping was unscrewed and the custom tray was retrieved from the master model (Fig.39f). A total of thirty open tray implant level impressions were made on three different coping designs of ten each (n=10) using polyether impression material.

c. Impressions with vinylpolysiloxane material with three different impression copings (Fig.40)

The open tray implant level impression copings (Nobel active, Biohorizon and MIS) were connected to the respective master models with the help of their screw drivers (Fig.40a).The custom tray was coated with uniform layer of vinylpolysiloxane tray adhesive (Fig.40b) (3M ESPE, Germany) and allowed to dry for fifteen minutes as per the manufacturers' recommendation. Putty vinylpolysiloxane impression material (Express XT Penta Putty, 3M ESPE, Germany) was machine mixed (Pentamix 2, 3M ESPE, Seinfeld, Germany) and loaded into the custom tray (Fig.40c) keeping the tip immersed in the material all the time. The light body (Light body Express XT, 3M ESPE, Germany) was syringed around the impression coping by another operator simultaneously (Fig.40d). The tray was then positioned on the master model immediately (Fig40e). The excess material that had flown over the top of the coping screw was removed to expose the coping screw through the window in the custom tray. The impression was allowed to set undisturbed for 3 minutes as per the manufacturers' recommendation. After ensuring the complete set of impression material, the coping screw was unscrewed and the impression was retrieved from the master model (Fig.40 f). A total of thirty open tray implant level impressions were made on three different coping designs of ten each (n=10) using vinylpolysiloxane impression material.

IV. Grouping of impressions (Test samples)

In total, 90 impressions were made on three different open tray implant level impression copings with three different impression materials. The impressions were grouped as mentioned below for the evaluating the influence of open tray implant level impression coping design on the rotational resistance offered by three different impression materials.

Group I: Nobel active open tray implant level impression coping with vinylsiloxanether impression material.

Group II: Nobel active open tray implant level impression coping with polyether impression material.

Group III: Nobel active open tray implant level impression coping with vinylpolysiloxane impression material.

Group IV: Biohorizon open tray implant level impression coping with vinylsiloxanether impression material.

Group V: Biohorizon open tray implant level impression coping with polyether impression material.

Group VI: Biohorizon open tray implant level impression coping with vinylpolysiloxane impression material.

Group VII: MIS open tray implant level impression coping with vinylsiloxanether impression material.

Group VIII: MIS open tray implant level impression coping with polyether impression material.

Group IX: MIS open tray implant level impression coping with vinylpolysiloxane impression material.

V. Evaluation of rotational resistance (Fig.41-44)

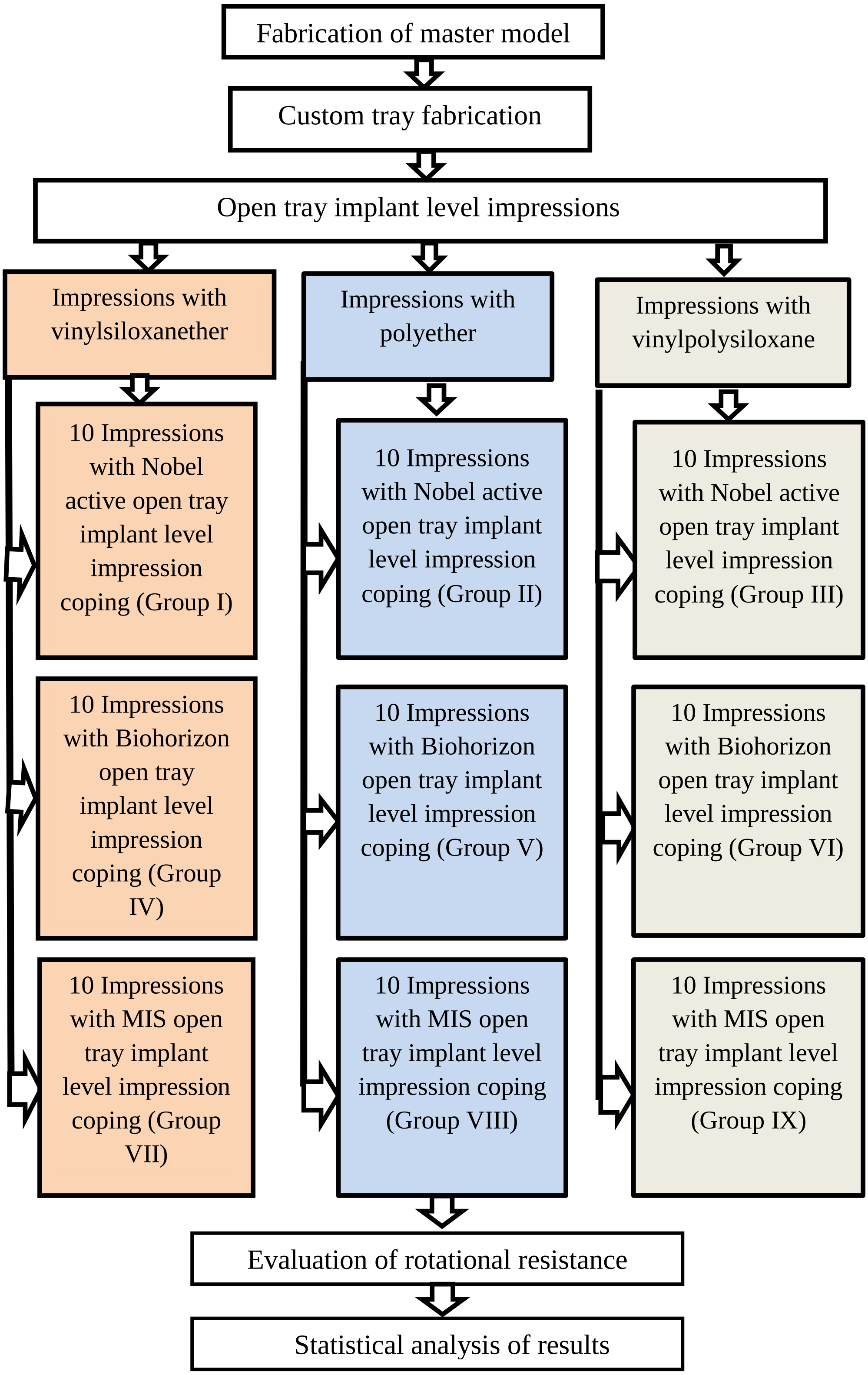
a. Connecting the implant replica to the impression coping (Fig.41)

The implant replica of the corresponding system was connected to the impression coping inside the impression with a screw driver. Gentle hand tightening was done to secure the implant replica to the impression coping (Fig.41a, b, c).

b. Evaluation of rotational resistance with digital screw torque checker (Fig 42-44)

The screw drivers of three different implant systems were fixed to the adapter of the digital screw torque checker (Fig.42). The adapter was connected to the digital screw torque checker. The ratchet change-over knob of the digital screw torque checker was adjusted to 'L' position (Fig.43a) and the memory number was assigned in the digital screw torque checker to each impression before checking the rotational resistance. Digital screw torque checker was used to torque the coping screws by turning the plastic handle in clock-wise direction until the rotation of impression coping. As the coping screws were tightened, the increasing torque values were displayed on the digital screw torque checker. Once the peak values were achieved there was a decrease in the torque values, indicating the rotation of the impression coping within the impression. The peak torque value was alone displayed on the digital screw torque checker. The auto-memory function of this device stored the peak torque value obtained for that impression (Fig.44a,b). This torque value represented the rotational resistance offered by the impression material when using the particular design of impression coping. The same procedure was repeated for all the 90 impressions to evaluate the rotational resistance of three different impression materials with three different impression coping designs. The results were tabulated and subjected to statistical analysis.

METHODOLOGY – OVERVIEW



MATERIALS

Fig.1: Clear autopolymerizing acrylic resin

Fig.2: Implant Replica (Nobel active)

Fig.3: Implant Replica (Biohorizon)

Fig.4: Implant Replica (MIS)

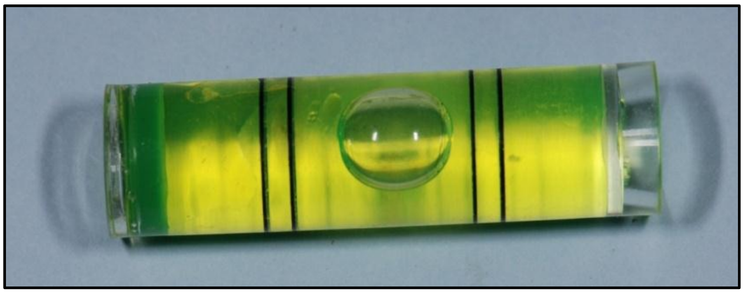


Fig.5: Spirit level indicator

Fig.6: Light cure resin sheet

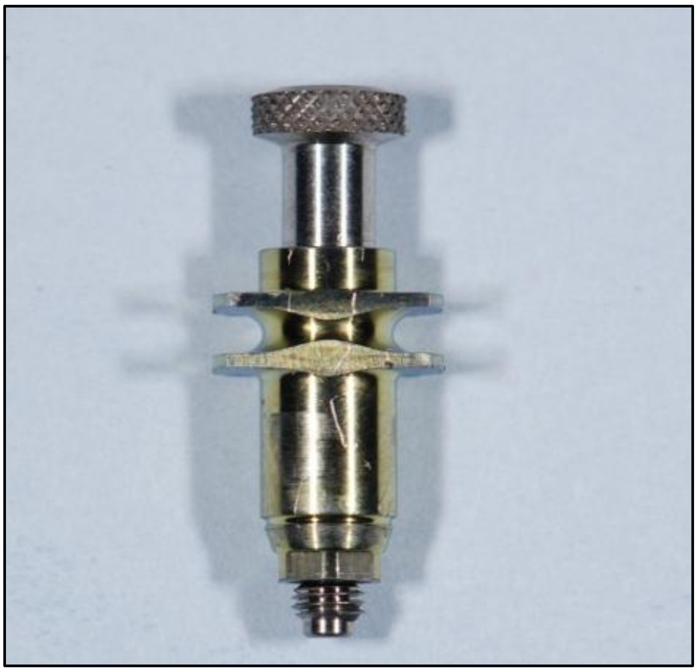


Fig.7a: Nobel active open tray implant level impression coping

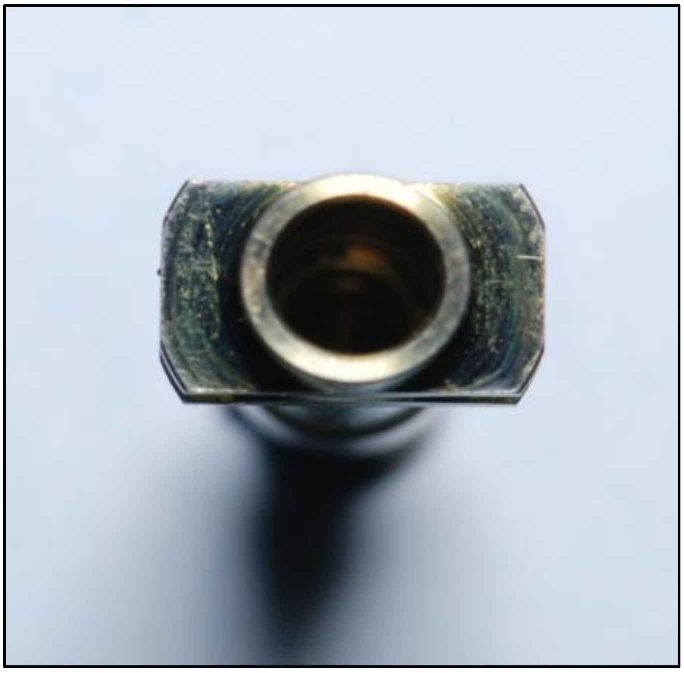


Fig.7b: Nobel active open tray implant level impression coping from occlusal view

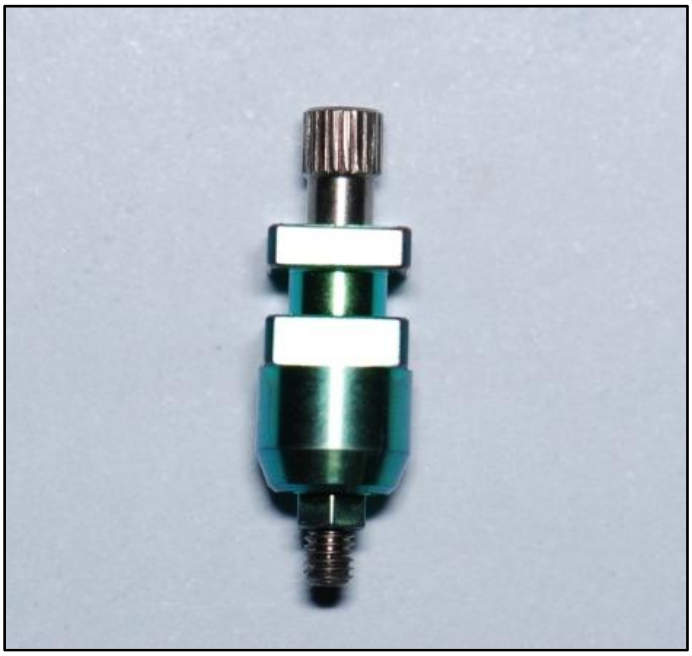


Fig.8a: Biohorizon open tray implant level impression coping

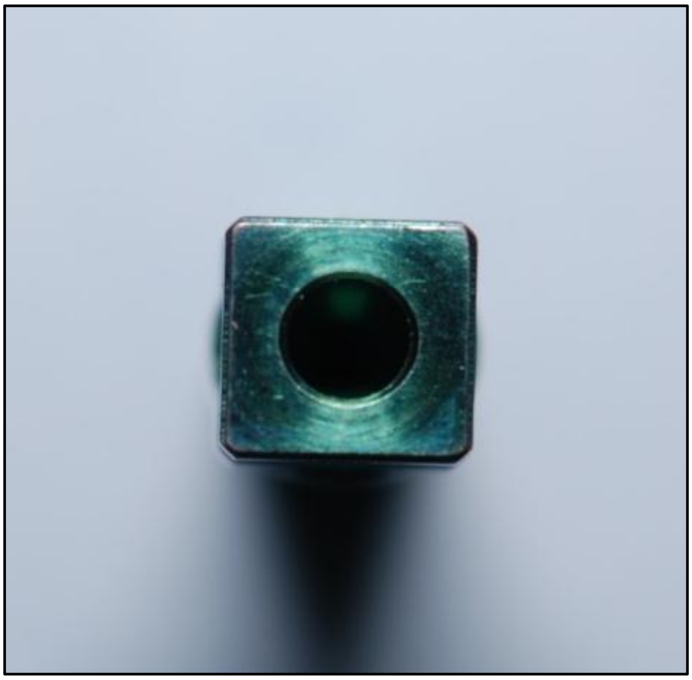


Fig.8b: Biohorizon open tray implant level impression coping from occlusal view

Fig.9a: MIS open tray implant level impression coping

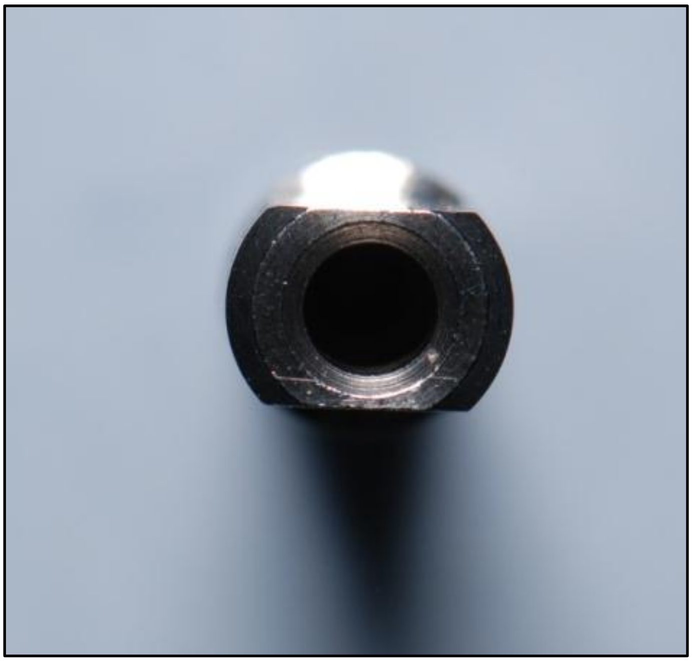


Fig.9b: MIS open tray implant level impression coping from occlusal view

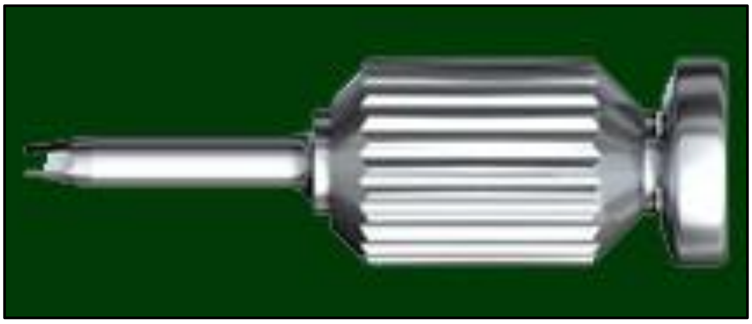


Fig.10: Nobel Active Screw Driver

Fig.11: Biohorizon Screw Driver

Fig.12: MIS Screw Driver

Fig.13: Vinylsiloxanether Impression Material

Fig.14: Vinylsiloxanether Tray Adhesive

Fig.15: Polyether Impression Material

Fig.16: Polyether Tray Adhesive

Fig.17: Vinylpolysiloxane Impression Material – Putty

Fig.18: Vinylpolysiloxane Tray adhesive

Fig.19: Vinylpolysiloxane light Body

Fig.20: Auto mixing Gun

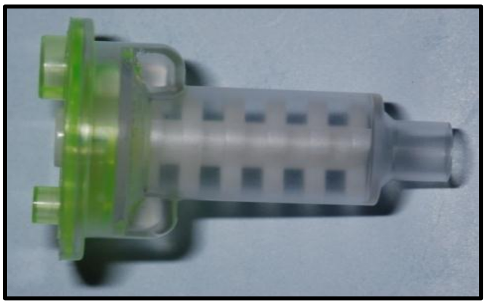


Fig.21: Auto mixing spiral for vinylsiloxanether

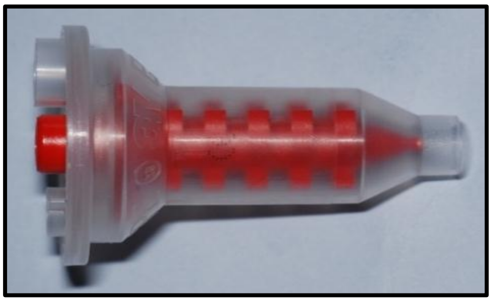


Fig.22: Auto mixing spiral for polyether and vinylpolysiloxane

Fig.23: Auto mixing spiral with intraoral tip for light body vinylpolysiloxane

Fig.24: Penta syringe for polyether and vinylsiloxanether

Fig.25: Epoxy compound

EQUIPMENTS

Fig.26: Dental Surveyor

Fig.27: Light Cure Unit

Fig.28: Pentamix auto mixing unit

Fig.29: Digital Screw Torque Checker

METHODOLOGY

I. FABRICATION OF MASTER MODELS

Fig.30: Custom made stainless steel blocks

Fig.31: Surveyor with stainless steel block

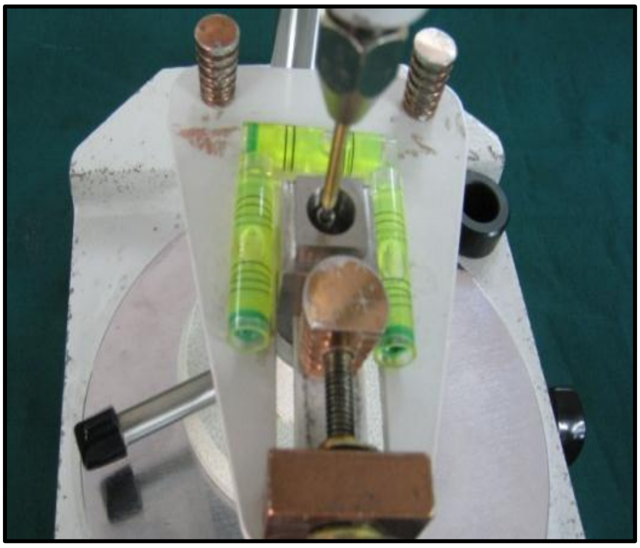


Fig.32: Placement of the implant replica

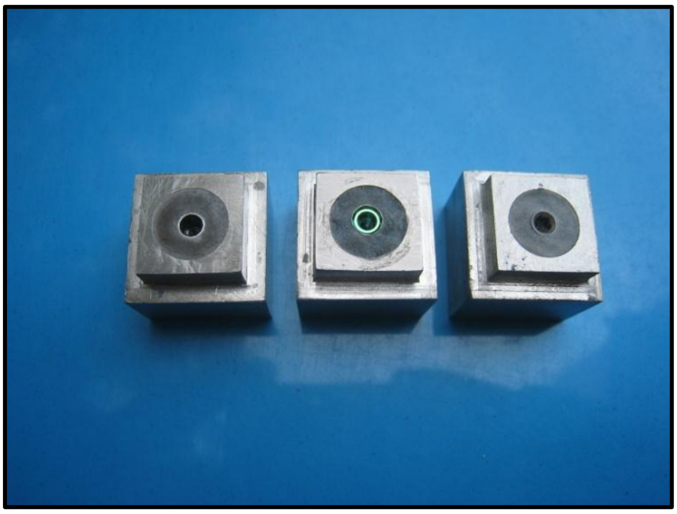


Fig.33: Implant replicas positioned with autopolymerizing acrylic resin in the master models

II. CUSTOM TRAY FABRICATION

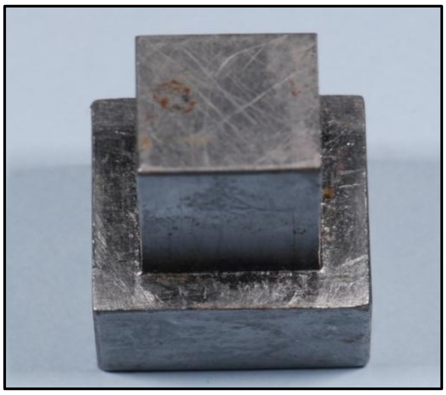


Fig.34: Custom made stainless steel block for making custom tray

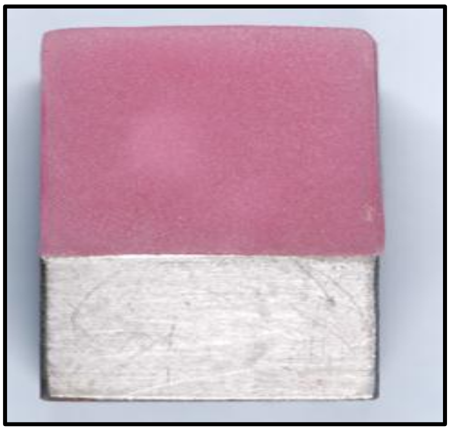


Fig.35: Adaptation of light cure sheet over stainless steel block

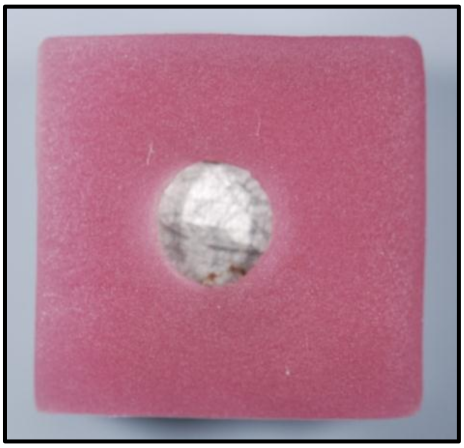


Fig.36: light cure custom tray with occlusal opening

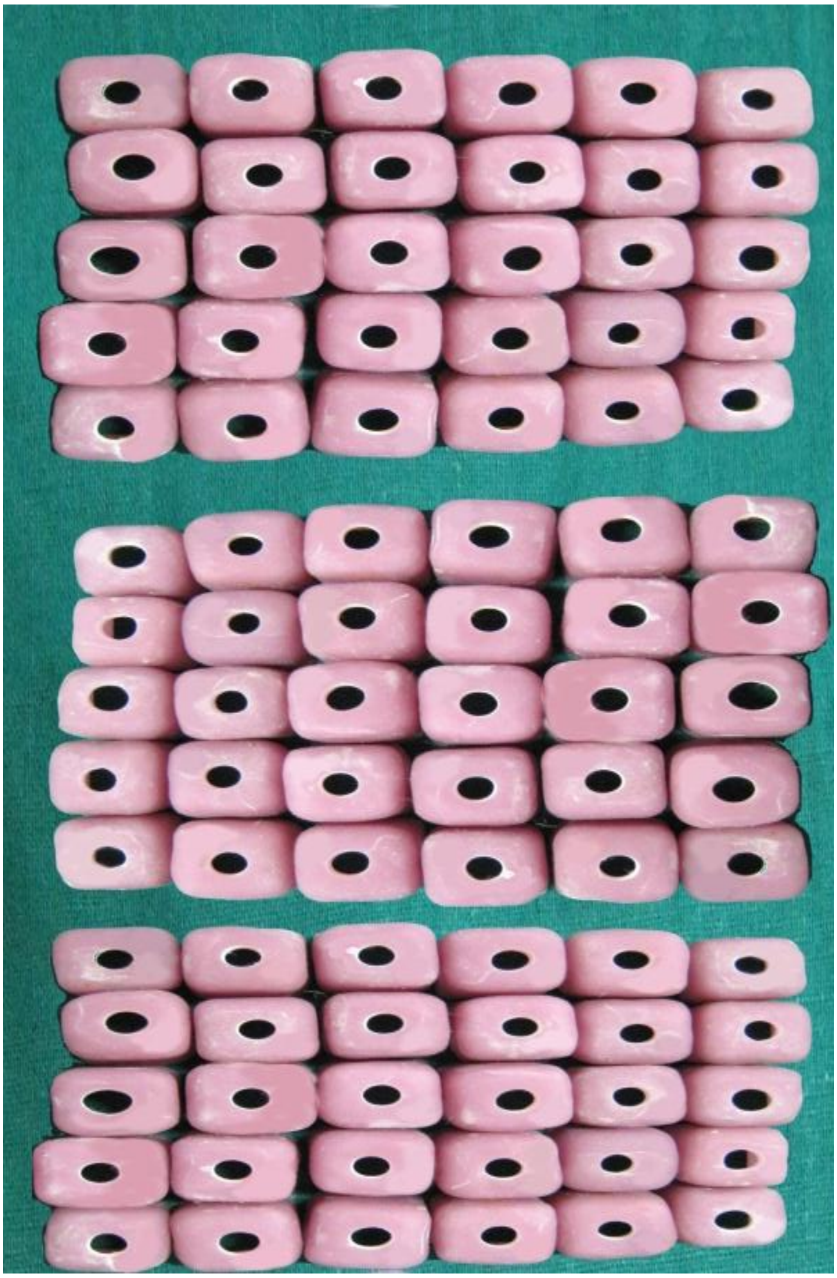


Fig.37: Finished custom trays

III. OPEN TRAY IMPLANT LEVEL IMPRESSIONS

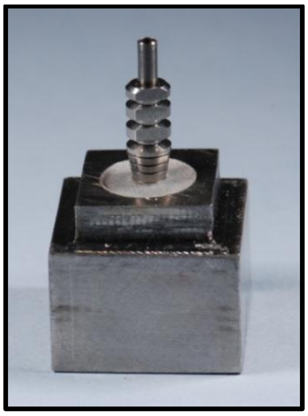


Fig. 38a: MIS open tray implant level impression coping connected to master model

Fig. 38b: Application of vinylsiloxanether tray adhesive

Fig. 38c: Vinylsiloxanether loaded into the custom tray

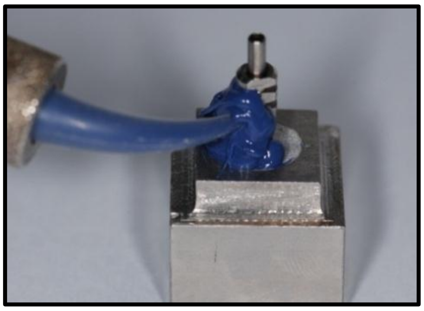


Fig. 38d: Vinylsiloxanether injected around the impression coping

Fig. 38e: Tray positioned on the master model

Fig. 38f: Impression retrieved from the master model

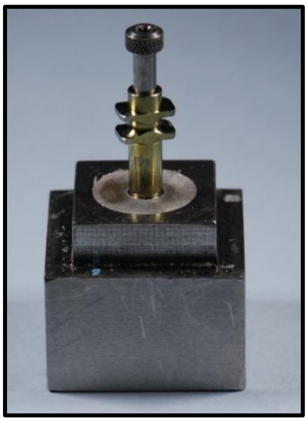


Fig. 39a: Nobel active open tray implant level impression coping connected to master model

Fig. 39b: Application of polyether tray adhesive

Fig. 39c: Polyether loaded into the custom tray

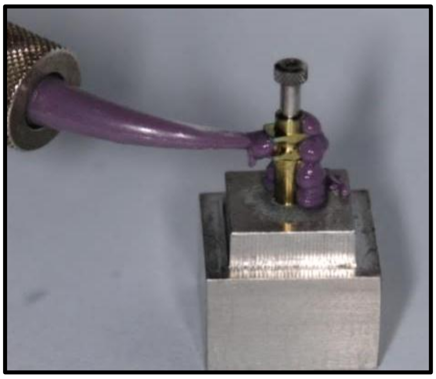


Fig. 39d: Polyether injected around the impression coping

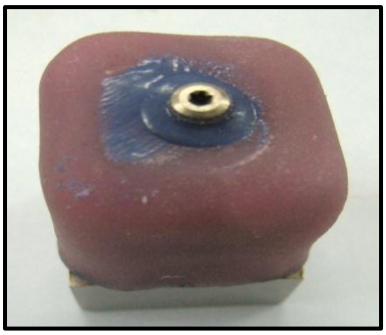


Fig. 39e: Tray positioned on the master model

Fig. 39f: Impression retrieved from the master model

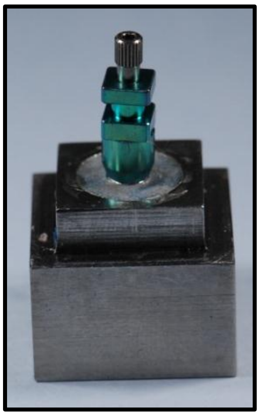


Fig. 40a: Biohorizon open tray implant level impression coping connected to master model

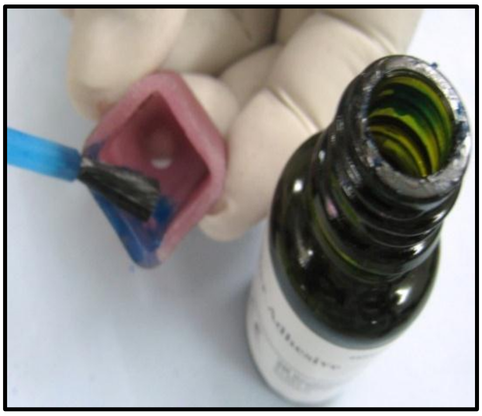


Fig. 40b: Application of vinylpolysiloxane tray adhesive

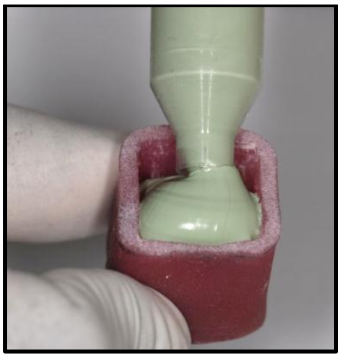


Fig. 40c: vinylpolysiloxane loaded into the custom tray

Fig. 40d: Light body was injected around the impression coping

Fig. 40e: Tray positioned on the master model

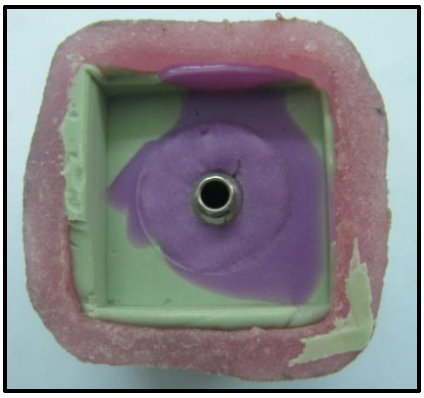


Fig. 40f: Impression retrieved from the master model

IV EVALUATION OF ROTATIONAL RESISTANCE

a. Connecting the implant replica to the impression coping

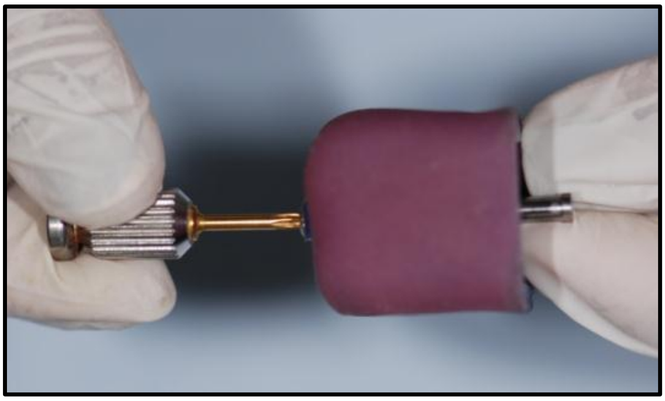


Fig. 41a: Connecting implant replica to Nobel active impression coping

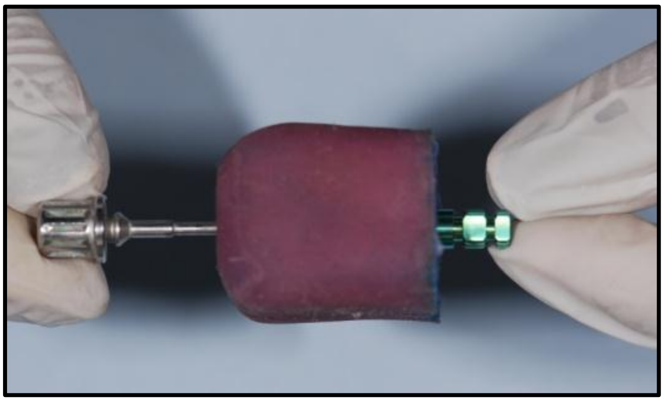


Fig. 41b: Connecting implant replica to Biohorizon impression coping

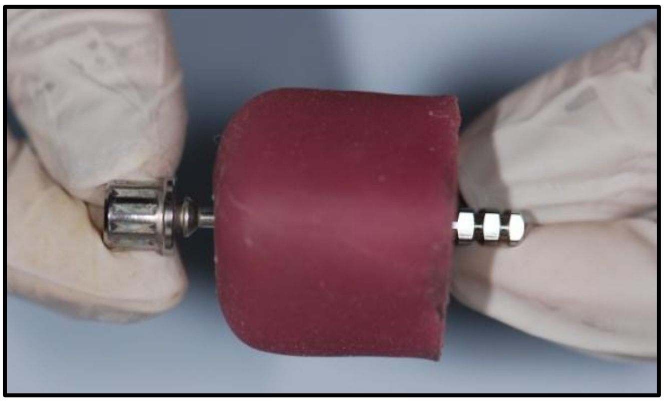


Fig. 41c: Connecting implant replica to MIS impression coping

b. Evaluation of rotational resistance with digital screw torque checker

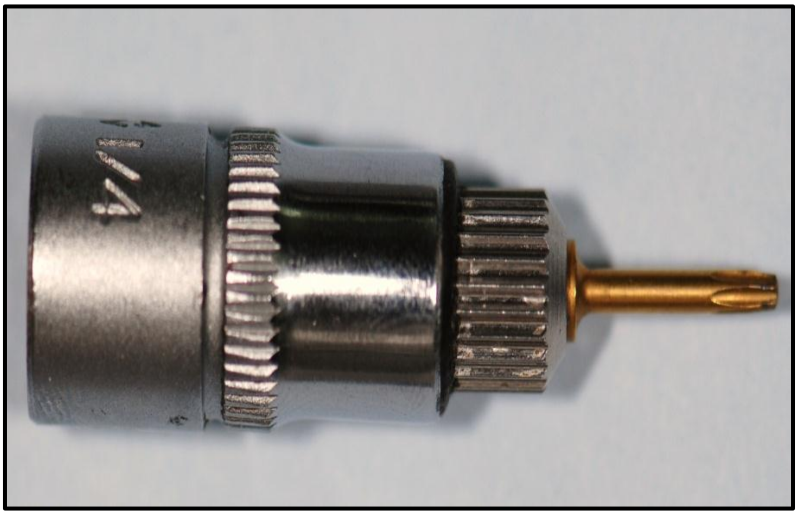


Fig.42: Adapted screw driver to digital screw torque checker

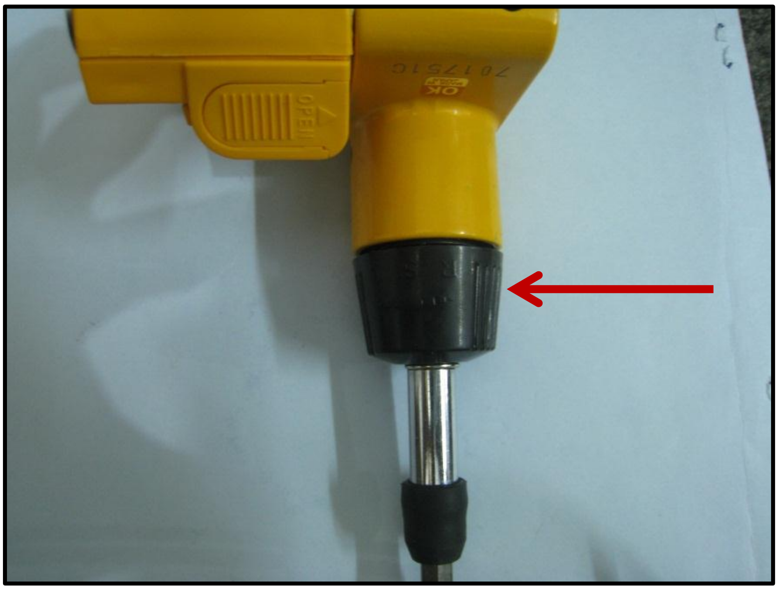


Fig.43: Rachet change-over knob adjusted to ‘L’ position

Fig. 44a: Digital screw torque checker evaluating the rotational resistance

Fig. 44b: Display of the peak torque values recoded by the Digital screw torque checker

RESULTS

The present in vitro study was conducted to evaluate comparatively the influence of open tray implant level impression copings designs on the rotational resistance offered by three different impression materials.

The following results were obtained from the study which were evaluated and compared the rotational resistance offered by three different impression materials with three different open tray implant level impression coping designs.

Mean and standard deviation (S.D) of all the values for each group were obtained and they were statistically analysed by using one way ANOVA, Post-hoc Tukey HSD test.

Table 1 shows the basic values of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Nobel active open tray implant level impression copings (Group I, Group II, and Group III).

Table 2 shows the basic values of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Biohorizon open tray implant level impression copings (Group IV, Group V, and Group VI).

Table 3 shows the basic values of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with MIS open tray implant level impression copings (Group VII, Group VIII, and Group IX).

Table 4 shows the comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Nobel active open tray implant level impression coping (Group I, Group II, and Group III).

Table 5 shows the comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Biohorizon open tray implant level impression coping (Group IV, Group V, and Group VI).

Table 6 shows the comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with MIS open tray implant level impression coping (Group VII, Group VIII, and Group IX).

Table 7 shows the comparative evaluation of the rotational resistance offered by vinylsiloxanether impression material with Nobel active, Biohorizon, and MIS open tray implant level impression copings (Group I, Group IV, and Group VII).

Table 8 shows the comparative evaluation of the rotational resistance offered by polyether impression material with Nobel active, Biohorizon, and MIS open tray implant level impression copings (Group II, Group V, and Group VIII).

Table 9 shows the comparative evaluation of the rotational resistance offered vinylpolysiloxane impression material with Nobel active, Biohorizon, and MIS open tray implant level impression copings (Group III, Group VI, and Group IX)**.**

Graph 1 shows the basic values of the rotational resistance offered by vinylsiloxanether impression material with Nobel active open tray implant level impression coping (Group I).

Graph 2 shows the basic values of the rotational resistance offered by polyether impression material with Nobel active open tray implant level impression coping (Group II).

Graph 3 shows the basic values of the rotational resistance offered by vinylpolysiloxane impression material with Nobel active open tray implant level impression coping (Group III).

Graph 4 shows the basic values of the rotational resistance offered by vinylsiloxanether impression material with Biohorizon open tray implant level impression coping (Group IV).

Graph 5 shows the basic values of the rotational resistance offered by polyether impression material with Biohorizon open tray implant level impression coping (Group V).

Graph 6 shows the basic values of the rotational resistance offered by vinylpolysiloxane impression material with Biohorizon open tray implant level impression coping (Group VI).

Graph 7 shows the basic values of the rotational resistance offered by vinylsiloxanether impression material with MIS open tray implant level impression coping (Group VII).

Graph 8 shows the basic values of the rotational resistance offered by polyether impression material with MIS open tray implant level impression coping (Group VIII).

Graph 9 shows the basic values of the rotational resistance offered by vinylpolysiloxane impression material with MIS open tray implant level impression coping (Group IX).

Graph 10 shows the comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Nobel active open tray implant level impression coping (Group I, Group II, and Group III).

Graph 11 shows the comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Biohorizon open tray implant level impression coping (Group IV, Group V, and Group VI).

Graph 12 shows the comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with MIS open tray implant level impression coping (Group VII, Group VIII, and Group IX).

Graph 13 shows the comparative evaluation of the rotational resistance offered by vinylsiloxanether impression material with Noble active, Biohorizon and MIS open tray implant level impression copings (Group I, Group IV, and Group VII).

Graph 14 shows the comparative evaluation of the rotational resistance offered by polyether impression material with Noble active, Biohorizon and MIS open tray implant level impression copings (Group II, Group V, and Group VIII).

Graph 15 shows the comparative evaluation of the rotational resistance offered by vinylpolysiloxane impression material with Noble active, Biohorizon and MIS open tray implant level impression copings (Group III, Group VI, and Group IX).

Table 1: Basic values of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Nobel active open tray implant level impression coping (Group I, Group II, and Group III).

Sample No	Vinylsiloxanether Group I (N.cm)	Polyether Group II (N.cm)	Vinylpolysiloxane Group III (N.cm)
1	11.15	10.25	17.20
2	11.25	12.35	13.40
3	11.05	10.60	14.00
4	11.35	12.60	16.20
5	11.70	13.75	16.45
6	11.25	10.45	13.65
7	12.55	14.10	16.95
8	13.35	12.20	18.25
9	10.80	11.70	17.70
10	12.30	10.45	17.35
Mean/Standard Deviation	**11.67/0.80**	**11.84/1.40**	**16.11/1.77**

INFERENCE: The mean rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Nobel active open tray implant level impression copings were 11.67, 11.84, 16.11 N.cm respectively.

Table 2: Basic values of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Biohorizon open tray implant level impression coping (Group IV, Group V, and Group VI).

Sample No	Vinylsiloxanether Group IV (N.cm)	Polyether Group V (N.cm)	Vinylpolysiloxane Group VI (N.cm)
1	11.05	11.70	12.75
2	10.25	15.30	16.35
3	11.04	18.60	17.95
4	9.05	16.05	20.05
5	11.70	18.30	15.35
6	10.80	20.75	15.95
7	15.35	21.70	18.45
8	14.35	15.75	22.85
9	14.35	19.10	19.05
10	14.65	17.35	14.50
Mean/Standard Deviation	**12.25/2.20**	**17.46/2.91**	**17.32/2.94**

INFERENCE: The mean rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Biohorizon open tray implant level impression copings were 12.25, 17.46, 17.32 N.cm respectively.

Table 3: Basic values of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with MIS open tray implant level impression coping (Group VII, Group VIII, and Group IX).

Sample No	Vinylsiloxanether Group VII (N.cm)	Polyether Group VIII (N.cm)	Vinylpolysiloxane Group IX (N.cm)
1	8.50	11.60	7.00
2	7.95	11.80	7.65
3	6.45	11.20	7.35
4	6.00	11.70	7.60
5	5.35	13.60	4.85
6	8.60	14.50	4.38
7	7.85	13.25	9.20
8	8.05	15.20	8.60
9	8.00	13.20	9.05
10	8.25	13.65	7.95
Mean/Standard Deviation	**7.50/1.13**	**12.97/1.34**	**7.36/1.61**

INFERENCE: The mean rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with MIS open tray implant level impression copings were 7.50, 12.97, 7.36 N.cm respectively.

Table 4: Comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Nobel active open tray implant level impression coping (Group I, Group II, and Group III).

One way analysis of variance (ANOVA):

Groups	Mean (N.cm)	Standard deviation	p- value
Group I	11.6750	.80700	0.000^{*}
Group II	11.8450	1.40128	
Group III	16.1150	1.77983	

$^{*}p < 0.05$, statistically significant

INFERENCE: One way ANOVA shows a statistically significant difference between the three groups of 5% level.

Post-hoc Tukey HSD analysis:

Groups	Mean (N.cm)	Standard Deviation	p-value
Group I	11.67	0.80	0.96
Group II	11.84	1.40	
Group II	11.84	1.40	0.00^{*}
Group III	16.11	1.77	
Group III	16.11	1.77	0.00*
Group I	11.67	0.80	

*$p < 0.05$, statistically significant

INFERENCE: Tukey HSD shows a statistically significant difference between Group II & Group III and Group III & Group I. Statistically significant difference was not found between Group I & Group II.

Table 5: Comparative evaluation the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Biohorizon open tray implant level impression coping (Group IV, Group V, and Group VI).

One way analysis of variance (ANOVA):

Groups	Mean (N.cm)	Standard deviation	p- Value
Group IV	12.2590	2.20450	0.000*
Group V	17.4600	2.91098	
Group VI	17.3250	2.94838	

***p< 0.05, statistically significant**

INFERENCE: One way ANOVA shows a statistically significant difference between the three groups of 5% level.

Post-hoc Tukey HSD analysis:

Groups	Mean (N.cm)	Standard Deviation	p-value
Group IV	12.2	2.20	0.001*
Group V	17.4	2.91	
Group V	17.4	2.91	0.993
Group VI	17.3	2.94	
Group VI	17.3	2.94	0.001*
Group IV	12.2	2.20	

*p< 0.05, statistically significant

INFERENCE: Tukey HSD shows a statistically significant difference between Group IV & Group V and Group VI & Group IV. Statistically significant difference was not found between Group V & Group VI.

Table 6: Comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with MIS open tray implant level impression coping (Group VII, Group VIII, and Group IX).

One way analysis of variance (ANOVA):

Groups	Mean (N.cm)	Standard deviation	p- Value
Group VII	7.5000	1.13652	
Group VIII	12.9700	1.34561	0.000*
Group IX	7.3630	1.61861	

*p< 0.05, statistically significant

INFERENCE: One way ANOVA shows a statistically significant difference between the three groups of 5% level.

Post-hoc Tukey HSD analysis:

Groups	Mean (N.cm)	Standard Deviation	p-value
Group VII	7.50	1.13	0.00*
Group VIII	12.97	1.34	
Group VIII	12.97	1.34	0.00*
Group IX	7.36	1.61	
Group IX	7.36	1.61	0.973
Group VII	7.50	1.13	

*p< 0.05, statistically significant

INFERENCE: Tukey HSD shows a statistically significant difference between Group VII & Group VIII and Group VIII & Group IX. Statistically significant difference was not found between Group IX & Group VII.

Table 7: Comparative evaluation of the rotational resistance offered by vinylsiloxanether impression material with Nobel active, Biohorizon, and MIS open tray implant level impression copings (Group I, Group IV, and Group VII).

One way analysis of variance (ANOVA):

Groups	Mean (N.cm)	Standard deviation	p- Value
Group I	11.67	.80	0.000^{*}
Group IV	12.25	2.20	
Group VII	7.50	1.13	

*p< 0.05, statistically significant

INFERENCE: One way ANOVA shows a statistically significant difference between the three groups of 5% level.

Post-hoc Tukey HSD analysis:

Groups	Mean (N.cm)	Standard Deviation	p-value
Group I	11.67	.80	0.66
Group IV	12.25	2.20	
Group IV	12.25	2.20	0.00^{*}
Group VII	7.50	1.13	
Group VII	7.50	1.13	0.00*
Group I	11.67	.80	

*p< 0.05, statistically significant

INFERENCE: Tukey HSD shows a statistically significant difference between Group IV & Group VII and Group VII & Group I. Statistically significant difference was not found between Group I & Group IV.

Table 8: Comparative evaluation of the rotational resistance offered by polyether impression material with Nobel active, Biohorizon, and MIS open tray implant level impression copings (Group II, Group V, and Group VIII).

One way analysis of variance (ANOVA):

Groups	Mean (N.cm)	Standard deviation	p- Value
Group II	11.84	1.40	0.00^{*}
Group V	17.46	2.91	
Group VIII	12.9	1.34	

*p< 0.05, statistically significant

INFERENCE: One way ANOVA shows a statistically significant difference between the three groups of 5% level.

Post-hoc Tukey HSD analysis:

Groups	Mean (N.cm)	Standard Deviation	p-value
Group II	11.84	1.40	0.00^{*}
Group V	17.46	2.91	
Group V	17.46	2.91	0.00*
Group VIII	12.97	1.34	
Group VIII	12.97	1.34	0.438
Group II	11.84	1.40	

*p< 0.05, statistically significant

INFERENCE: Tukey HSD shows a statistically significant difference between Group II & Group V and Group V & Group VIII. Statistically significant difference was not found between Group VIII & Group II.

Table 9: Comparative evaluation of the rotational resistance offered by vinylpolysiloxane impression material with Nobel active, Biohorizon, and MIS open tray implant level impression copings (Group III, Group VI, and Group IX).

One way analysis of variance (ANOVA)

Groups	Mean (N.cm)	Standard deviation	p- Value
Group III	16.11	1.77	0.000*
Group VI	17.32	2.94	
Group IX	7.36	1.61	

*p< 0.05, statistically significant

INFERENCE: One way ANOVA shows a statistically significant difference between the three groups of 5% level.

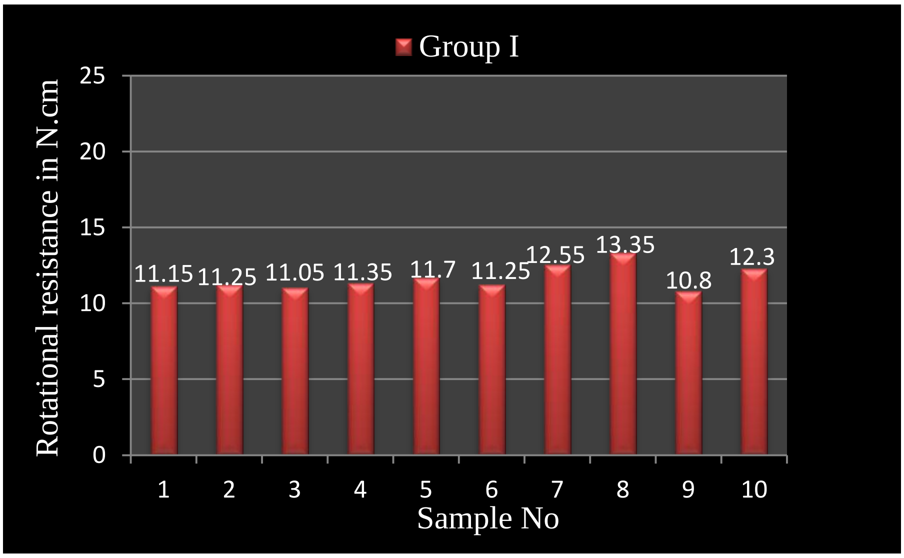
Post-hoc Tukey HSD analysis:

Groups	Mean (N.cm)	Standard Deviation	p-value
Group III	16.11	1.77	0.445
Group VI	17.32	2.94	
Group VI	17.32	2.94	0.00*
Group IX	7.36	1.61	
Group IX	7.36	1.61	0.00*
Group III	16.11	1.71	

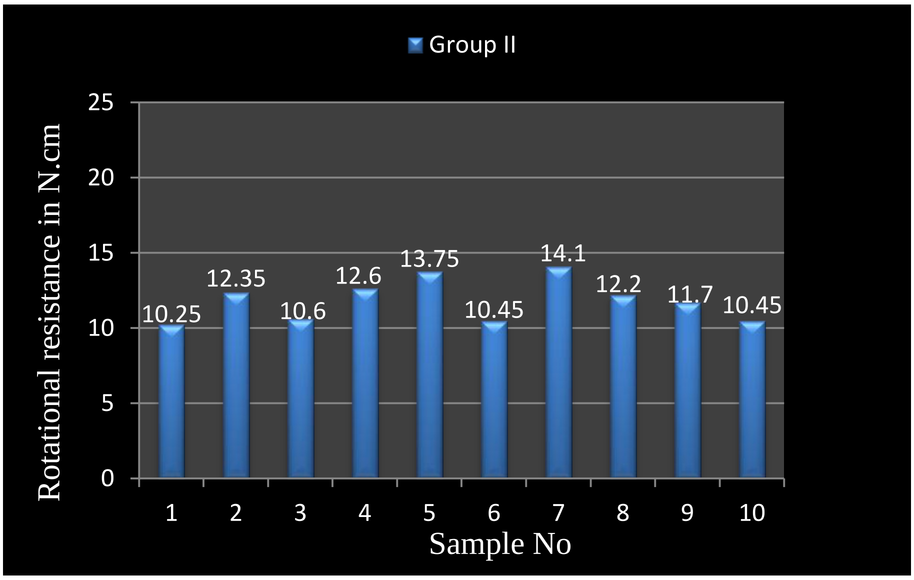
*p< 0.05, statistically significant

INFERENCE: Tukey HSD shows a statistically significant difference between Group VI & Group IX and Group IX & Group III. Statistically significant difference was not found between Group III & Group VI.

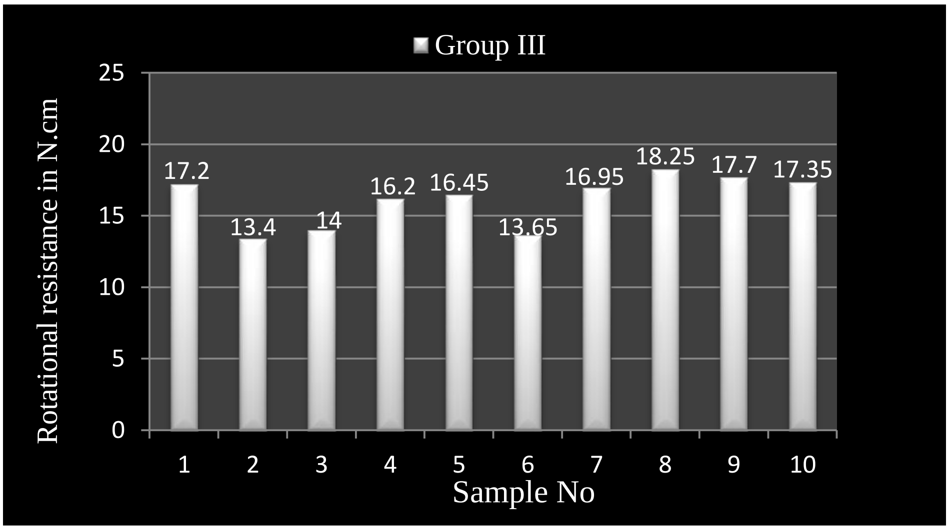
Graph 1: Basic values of the rotational resistance offered by vinylsiloxanether impression material with Nobel active open tray implant level impression coping (Group I).



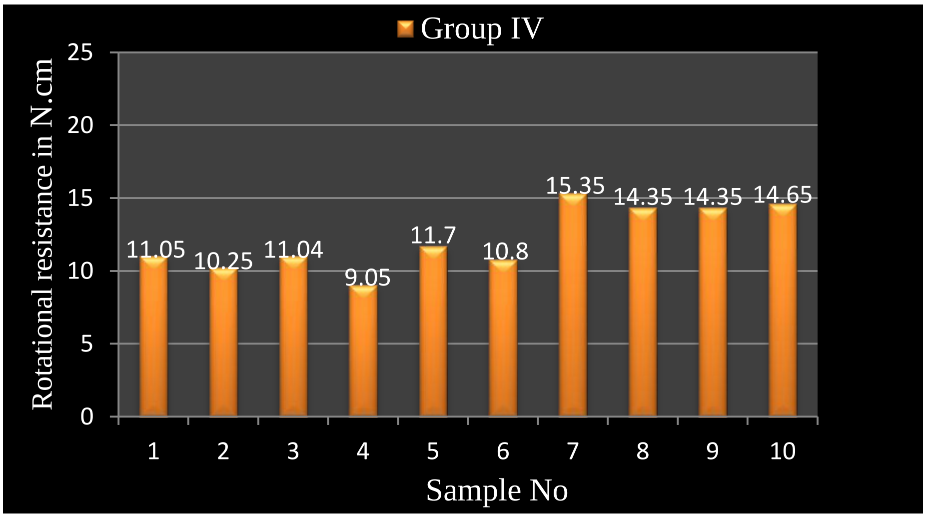
Graph 2: Basic values of the rotational resistance offered by polyether impression material with Nobel active open tray implant level impression coping (Group II).



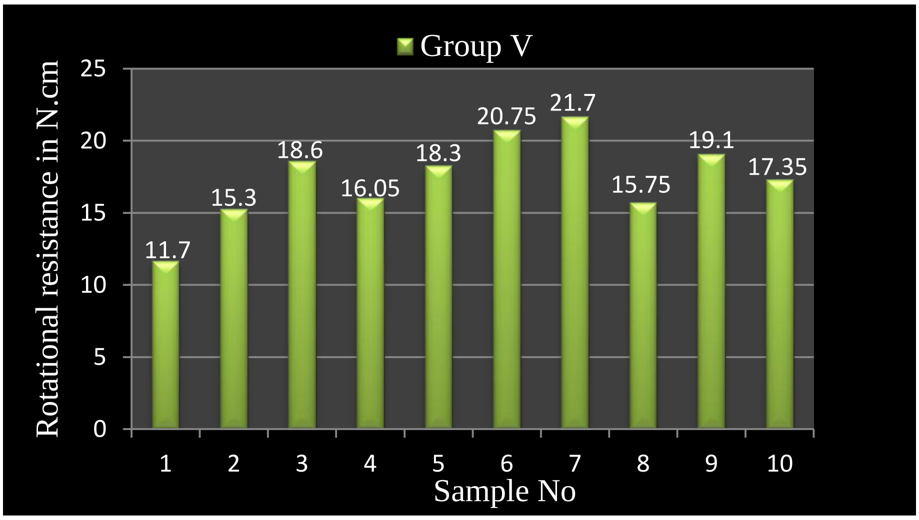
Graph 3: Basic values of the rotational resistance offered by vinylpolysiloxane impression material with Nobel active open tray implant level impression coping (Group III).



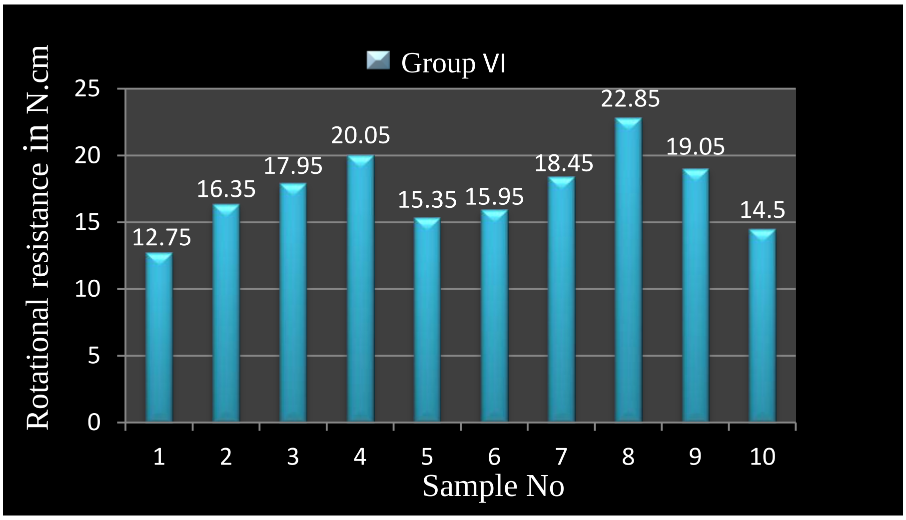
Graph 4: Basic values of the rotational resistance offered by vinylsiloxanether impression material with Biohorizon open tray implant level impression coping (Group IV).



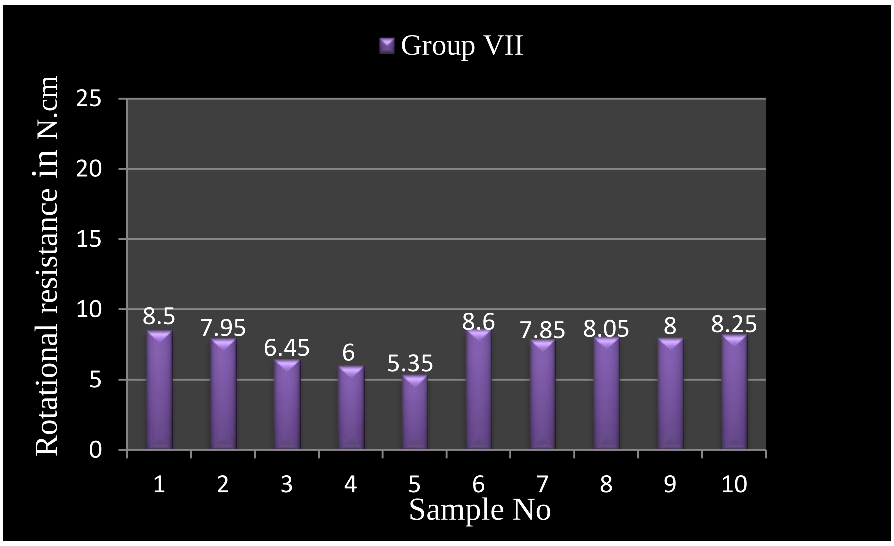
Graph 5: Basic values of the rotational resistance offered by polyether impression material with Biohorizon open tray implant level impression coping (Group V).



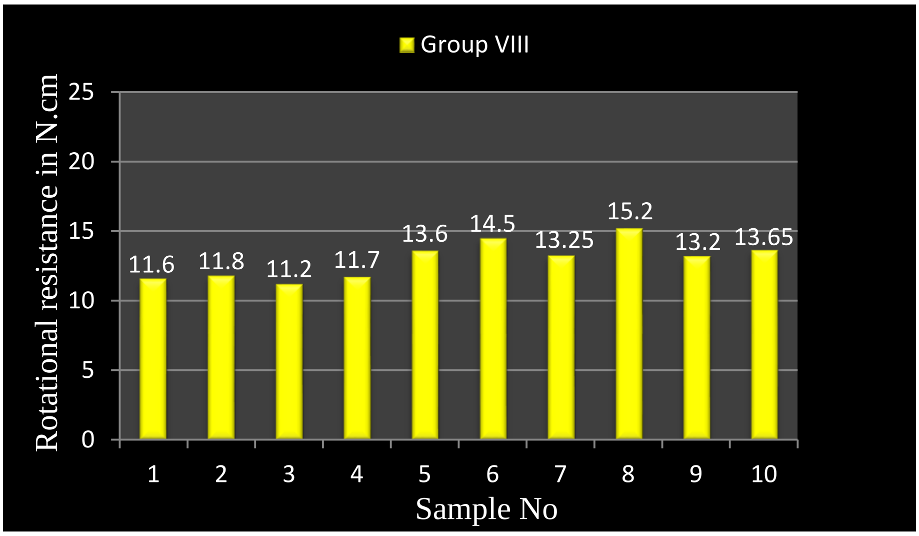
Graph 6: Basic values of the rotational resistance offered by vinylpolysiloxane impression material with Biohorizon open tray implant level impression coping (Group VI).



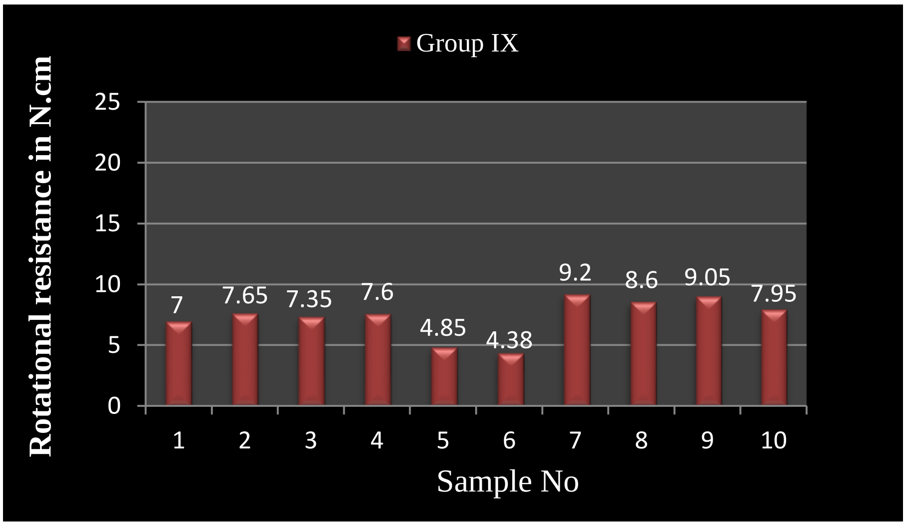
Graph 7: Basic values of the rotational resistance offered by vinylsiloxanether impression material with MIS open tray implant level impression coping (Group VII).



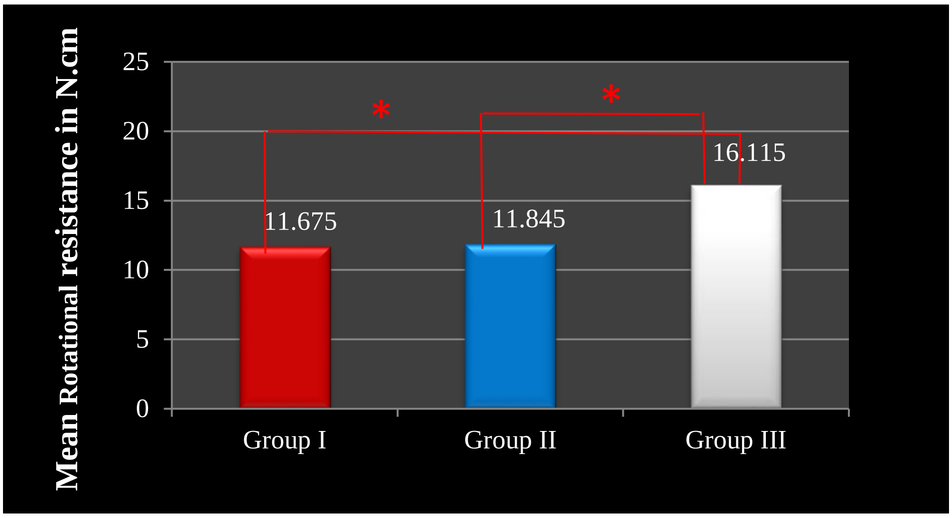
Graph 8: Basic values of the rotational resistance offered by polyether impression material with MIS open tray implant level impression coping (Group VIII).



Graph 9: Basic values of the rotational resistance offered by vinylpolysiloxane impression material with MIS open tray implant level impression coping (Group IX).

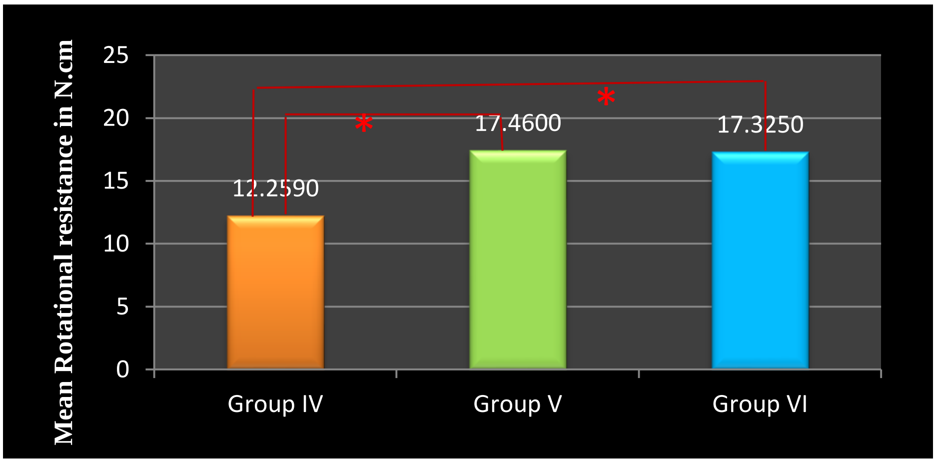


Graph 10: Comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Nobel active open tray implant level impression coping (Group I, Group II, and Group III).



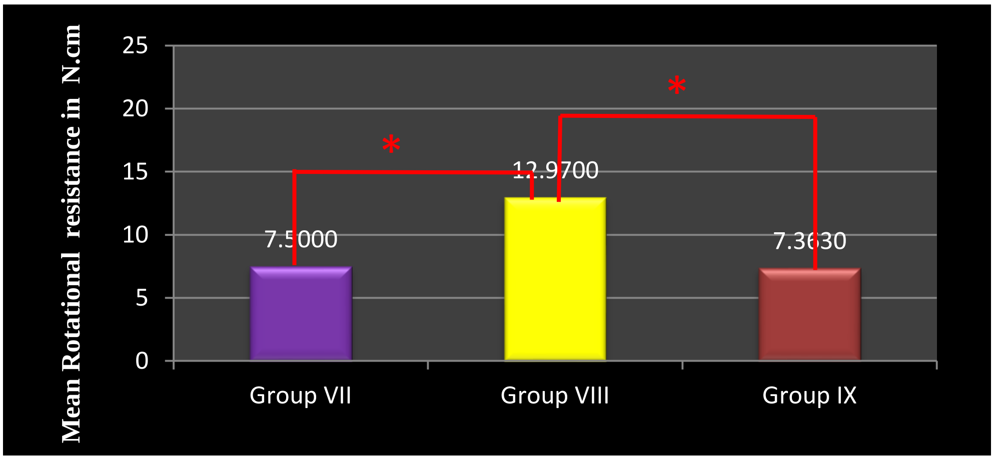
Note: * The mean difference is significant at the 0.05 level.

Graph 11: Comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with Biohorizon open tray implant level impression coping (Group IV, Group V, and Group VI).



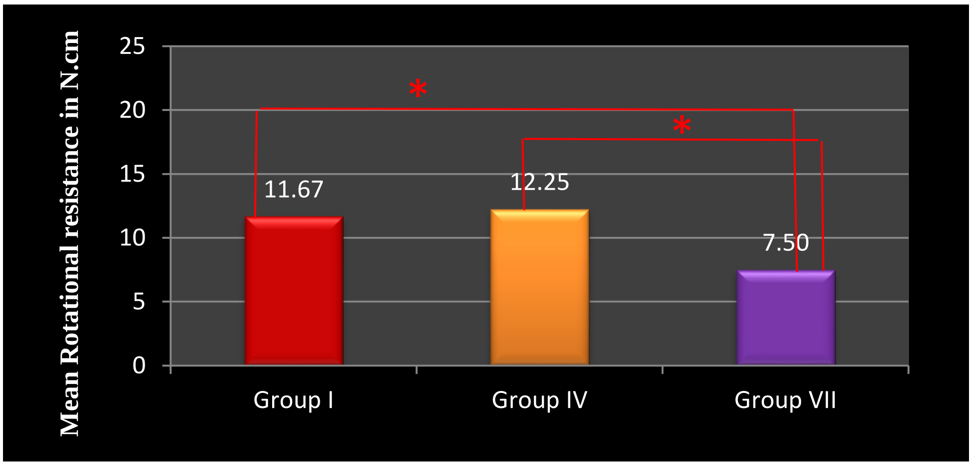
Note: * The mean difference is significant at the 0.05 level.

Graph 12: Comparative evaluation of the rotational resistance offered by vinylsiloxanether, polyether, and vinylpolysiloxane impression materials with MIS open tray implant level impression coping (Group VII, Group VIII, and Group IX).



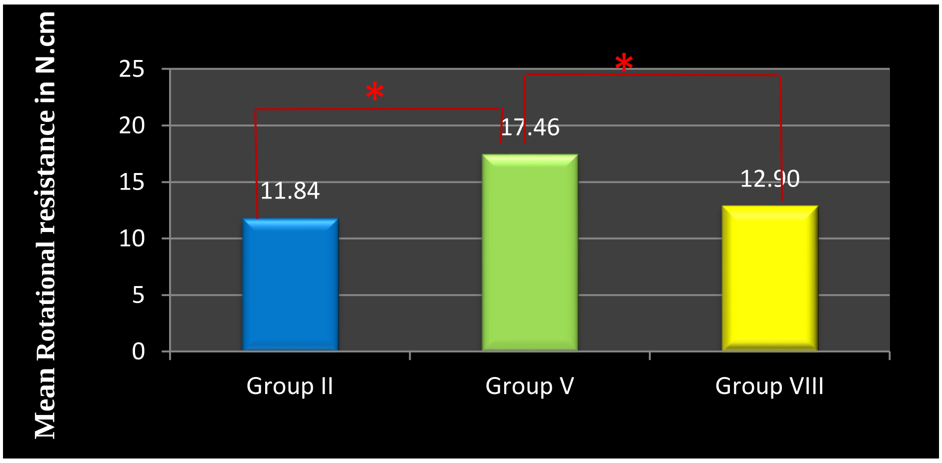
Note: * The mean difference is significant at the 0.05 level.

Graph 13: Comparative evaluation of the rotational resistance offered by vinylsiloxanether impression material with Noble active, Biohorizon and MIS open tray implant level impression copings (Group I, Group IV, and Group VII).



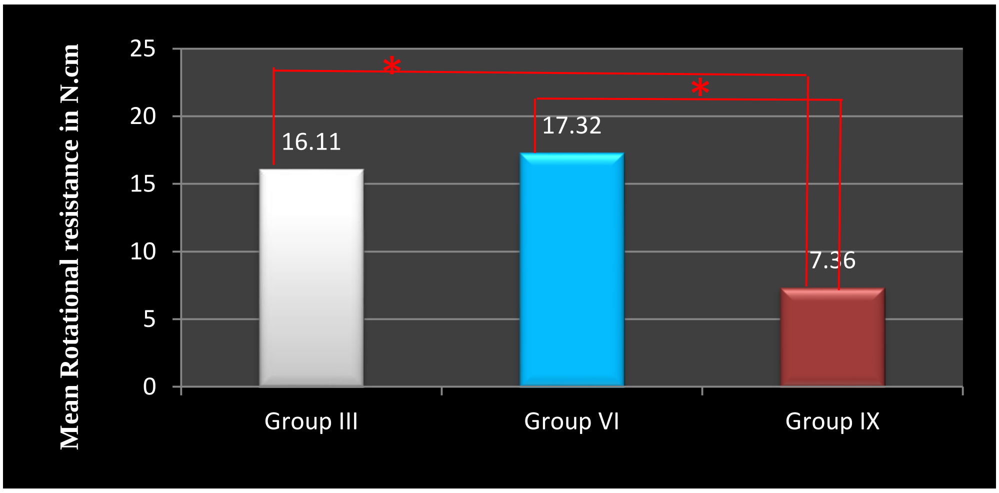
Note: * The mean difference is significant at the 0.05 level.

Graph 14: Comparative evaluation of the rotational resistance offered by polyether impression material with Noble active, Biohorizon and MIS open tray implant level impression copings (Group II, Group V, and Group VIII).



Note: * The mean difference is significant at the 0.05 level.

Graph 15: Comparative evaluation of the rotational resistance offered by vinylpolysiloxane impression material with Noble active, Biohorizon and MIS open tray implant level impression copings (Group III, Group VI, and Group IX).



Note: * The mean difference is significant at the 0.05 level.

DISCUSSION

The long-term success rate of osseointegrated implants has made implant–supported prostheses a valid option for the treatment of missing teeth. Reproducing the three dimensional intraoral relationships of implants through the accurate impression is the first step in achieving passively fitting prosthesis.[13]A passively fitting superstructure should theoretically induce absolute zero strain on the supporting implant components and the surrounding bone in the absence of the applied external load.[50]

An inaccurate impression may result in prosthesis misfit which may lead to mechanical and biological consequences that disrupt the function of dental implants. Mechanical complications include screw loosening, screw fracture, implant fracture and occlusal inaccuracies.[13] Biologic complications may include adverse tissue reactions, pain, tenderness, marginal bone loss, and loss of osseointegration.[13] Even though obtaining passive fit is practically impossible, minimizing the misfit to prevent possible complications is the goal of implant prosthodontic procedures.[13]

Several strategies have been suggested to reduce distortion of the implant framework. The accuracy of the implant master cast plays a vital role in improving fit. The accuracy of the implant cast depends on the type of implant impression technique, impression material, die material accuracy and the implant cast technique. Success in oral rehabilitation is dependent, in part, on the accurate registration of those structures that constitute the basis for prosthesis support. The impression which allows replication must be accurate and reproducible so that the resultant master cast precisely duplicates the clinical condition.

Various impression techniques such as open tray and closed tray techniques have been introduced and investigated for its accuracy. The advantage of closed tray technique is visual fastening of replica to the coping and therefore ensuring its complete seating.[3,13,61] However, elastic deformation may result from non-parallel implants while retrieving the impression tray from the mouth.[61] Reseating of the impression coping – implant replica assembly can also lead to errors in vertical axis.

The open tray technique allows for the impression coping to remain within the impression. This reduces the effect of the implant angulation, the deformation of the impression material upon recovery.[9,56,61.] But during fastening of the analog to the impression coping there are chances of rotation of coping within the impression thereby causing a rotational distortion. Various methods have been suggested by several authors such as splinting, and modification of impression copings to reduce the rotational tendency of the impression coping during the implant replica connection. However, splinting of impression copings is not possible in single implant or randomly distributed single implants in a partially edentulous arch. In such situations, the rotational tendency of the impression coping is influenced by rigidity of the impression material and the design of the open tray impression coping. The purpose of this study was to evaluate the influence of open tray implant level impression coping designs on the rotational resistance by three different impression materials.

In this study, three master models were fabricated by embedding the three different systems of implant replicas into the custom made stainless steel blocks with autopolymerizing acrylic resin. This was to resemble the single implant situation in a partially edentulous arch. A step design was incorporated on the periphery of the master model to act as stopper for the custom tray and the square shape of the master model was to prevent the rotation of the custom tray.

A stainless block was fabricated to standardize the uniform spacer thickness of 5mm for custom tray fabrication. A step design was also made on the periphery of the stainless steel block so that the custom tray was seated on the master model accurately while making the impression. The custom trays were made of light cure resin sheets that had an even thickness of 2mm to ensure rigidity and standardize the tray thickness. Light cure resin exhibit dimensional stability immediately after curing, thus allowing immediate clinical use after fabrication.

In this study vinylsiloxanether, polyether, and vinylpolysiloxane impression materials were used to evaluate the rotational resistance of impression copings within the set impression. Polyether and vinylpolysiloxane impression materials are the preferred over the other impression materials because of its rigidity, minimal positional distortion, and dimensional accuracy.[6,60,61] In this study newly introduced, vinylsiloxanether impression material was used, since this material possesses the advantages of vinylpolysiloxane and polyether impression material according to the manufacturer.

The respective tray adhesive of the impression material was applied to all the custom trays and allowed to dry according to the manufacturers recommendation. This procedure was done to prevent the delamination of set impression material upon removal of impression from the master model and to confine the impression material to custom tray while evaluating the rotational resistance. Medium body consistencies of polyether and vinylpolysiloxane impression material were machine mixed (Pentamix 2) in order to avoid errors resulting from improper mix and delivered around impression copings using a Pentasyringe to apply the impression material to avoid the defects around impression coping. Impressions with vinylpolysiloxane impression material were made by putty wash single stage technique. In this technique putty consistency material was machine mixed (Pentamix 2) and loaded in to the custom tray. The light body material was mixed using an auto-mixing gun and it was applied over the impression coping with an intraoral tip. This procedure was done to ensure the complete wetting of the impression material to the depth of undercuts of impression coping, since the inadequate flow character of the highly viscous putty consistency material. The loaded trays were seated on the step design of the master model to ensure equal bulk of impression material around the impression coping. After retrieval of the set impressions, they were evaluated with digital screw torque checker after one hour to ensure complete polymerization of impression material. This device has the sensitivity range of 0.05 N.cm. It has peak/run mode and built–in memory that can store up to 100 readings. The peak value of one particular sample can be displayed for 0.5-5.0 seconds. A similar device has been used by Wee in evaluating the rotational resistance offered by different impression materials[61].

Impressions made with vinylsiloxanether have resulted in torque values of 11.67, 12.25, 7.50 N.cm for Nobel active, Biohorizon, and MIS impression copings respectively. Resistance offered by Nobel active and Biohorizon impression copings are above 10 N.cm.[33] Whereas it is less than 10 N.cm for MIS impression coping. The literature shows that the maximum torque that can be achieved with finger tightening is about 10 N.cm. Therefore impression with this material in combination with Nobel active and Biohorizon impression copings have yielded acceptable rotational resistance.

Impressions made with polyether have resulted in torque values of 11.84, 17.46, 12.9 N.cm for Nobel active, Biohorizon and MIS impression copings respectively. The highest rotational resistance offered by polyether was in combination with the Biohorizon impression coping. The resistance offered with Nobel active, Biohorizon, and MIS impression copings when used with polyether yielded values above 10 N.cm. Thus polyether offered acceptable rotational resistance with all the three impression coping designs.

Impressions made with vinylpolysiloxane have resulted in torque values of 16.11, 17.32, 7.36 N.cm. for Nobel active, Biohorizon, and MIS copings respectively. The highest rotational resistance offered by vinylpolysiloxane was in combination with Biohorizon impression coping. The resistance offered by this material with Nobel active impression coping yielded values above 10 N.cm, while in combination with MIS impression coping the value was below the hand torquing ability of 10 N.cm. Thus vinylpolysiloxane proved to be an acceptable impression material for Nobel active and Biohorizon impression coping designs.

Impressions made using Nobel active impression coping have yielded torque values of 11.67, 11.84, and 16.11 N.cm with vinylpolysiloxanether, polyether, and vinylpolysiloxane impression materials respectively. The highest rotational resistance with this coping design was achieved in combination with vinylpolysiloxane impression material. Overall, Nobel active impression coping yielded acceptable rotational resistance with all the three impression materials.

Impressions made using Biohorizon impression coping have yielded torque values of 12.25, 17.46, and 17.32 N.cm with vinylpolysiloxanether, polyether, and vinylpolysiloxane impression materials respectively. This coping design has yielded very high rotational resistance in combination with polyether, vinylpolysiloxane impression materials. Also, the resistance achieved with Biohorizon impression coping is the highest with all the three impression materials when compared to Nobel active and MIS impression copings.

Impressions made using MIS impression copings have yielded torque values of 7.5, 12.97, and 7.36 N.cm with vinylpolysiloxanether, polyether, and vinylpolysiloxane impression materials respectively. The resistance offered in combination with polyether is above the maximum hand tightening torque level of 10 N.cm. Whereas in combination with vinylpolysiloxanether and vinylpolysiloxane the resistance is less than 10 N.cm, making them susceptible to rotation upon connection of implant replica.

The highest rotational resistance obtained with Biohorizon impression coping can be attributed to the flat, broad and square configuration of the coping design. Good values achieved with Nobel active impression coping can be because of the flat, rectangular surfaces. The slightly bevelled edges and lesser thickness of flat surfaces in the Nobel active impression coping design might be the reason for marginally lesser values in comparison to Biohorizon impression coping.

The poor values achieved with MIS impression coping can be attributed to the thin flat surfaces and curved edges of the impression coping. The curved edges adjacent to the flat surfaces might be the weak link facilitating rotation of impression coping inside the impression.

This study has not explored the influence of saliva, teeth, adjacent structures, bulk of impression material and the length of exposed impression coping on the rotational resistance offered by the impression material. Also, influence of coping modification like sandblasting, application of tray adhesive and its combination on rotational resistance have not been dealt within this study. Future research on rotational resistance offered by different impression materials for open tray implant level impressions can be done keeping in mind the above said factors.

CONCLUSION

The following conclusions were drawn based on the results obtained in this present in vitro study, which was conducted to comparatively evaluate the influence of open tray implant level impression copings designs on the rotational resistance offered by three different impression materials using a digital screw torque checker.

1. The mean rotational resistance offered by vinylsiloxanether (Group I), polyether (Group II), and vinylpolysiloxane (Group III) impression materials with Nobel active open tray implant level impression copings were 11.67, 11.84, 16.11 N.cm respectively.
2. The mean rotational resistance offered by vinylsiloxanether (Group IV), polyether (Group V), and vinylpolysiloxane (Group VI) impression materials with Biohorizon open tray implant level impression copings were 12.25, 17.46, 17.32 N.cm respectively.
3. The mean rotational resistance offered by vinylsiloxanether (Group VII), polyether (Group VIII), and vinylpolysiloxane (Group IX) impression materials with MIS open tray implant level impression copings were 7.50, 12.97, 7.36 N.cm respectively.
4. On comparison of the rotational resistance offered by vinylsiloxanether (Group I), polyether (Group II), and vinylpolysiloxane (Group III) impression materials with Nobel active open tray implant level impression copings showed statistically significant difference between Group II &

Group III and Group I & Group III but significant difference was not found between Group I & II.

5. On comparison of the rotational resistance offered by vinylsiloxanether (Group IV), polyether (Group V), and vinylpolysiloxane (Group VI) impression materials with Biohorizon open tray implant level impression copings showed statistically significant difference between Group IV & Group V and Group VI & Group IV but significant difference was not found between Group V & VI.
6. On comparison of the rotational resistance offered by vinylsiloxanether (Group VII), polyether (Group VIII), and vinylpolysiloxane (Group IX) impression materials with MIS open tray implant level impression copings showed statistically significant difference between Group VII & Group VIII and Group VIII & Group IX but significant difference was not found between Group IX & VII.
7. On comparison of the rotational resistance offered by vinylsiloxanether impression material with Nobel active (Group I), Biohorizon (Group IV), and MIS (Group VII) open tray implant level impression copings showed statistically significant difference between Group IV & Group VII and Group VII & Group I but significant difference was not found between Group I & IV.
8. On comparison of the rotational resistance offered by polyether impression material with Nobel active (Group II), Biohorizon (Group V), and MIS (Group VIII) open tray implant level impression copings showed

statistically significant difference between Group II & Group V and Group V & Group VIII but significant difference was not found between Group II & VIII.

9. On comparison of the rotational resistance offered by vinylpolysiloxane impression material with Nobel active (Group III), Biohorizon (Group VI) and MIS (Group IX) open tray implant level impression copings showed statistically significant difference between Group VI & Group IX and Group IX & Group III but significant difference was not found between Group III & VI.

SUMMARY

This study evaluated the influence of open tray implant level impression copings designs on the rotational resistance offered by three different impression materials.

Nobel active, Biohorizon, and MIS implant replicas were mounted in a custom made stainless steel block using autopolymerizing acrylic resin to develop the master models. The open tray implant level impression copings were connected to the respective master model with the screw driver of the respective implant system. A total of 90 custom trays were fabricated and divided into nine groups of ten each. Thirty impressions were made using Nobel active open tray implant level impression coping with vinylsiloxanether (n=10), polyether (n=10), and polyvinylsiloxane (n=10) impression materials. Similarly thirty impressions each were made using Biohorizon and MIS open tray implant level impression copings.

Implant replicas were connected to the respective impression copings by gentle hand tightening of the coping screw, to secure the implant replica to the impression coping. A digital screw torque checker was used to torque the coping screws to the implant replica until the rotation of the impression coping. The peak torque values indicating the maximum rotational resistance were recorded from the display of the digital screw torque checker. The mean values were obtained for all the 9 groups and subjected to statistical analysis.

The comparative evaluation of three impression materials with one coping design indicates that polyvinylsiloxane offered the highest rotational resistance for Nobel active open tray implant level impression copings followed by polyether and vinylsiloxanether impression material. Polyether offered highest rotational resistance for Biohorizon open tray implant level impression coping followed by vinylpolysiloxane and vinylsiloxanether impression material. Polyether offered highest rotational resistance for MIS open tray implant level impression coping followed by vinylsiloxanether and vinylpolysiloxane impression material.

The comparative evaluation of three coping designs with one impression material indicate that Biohorizon impression coping design offered the highest rotational resistance with all the three impression materials when compared to Nobel active and MIS impression copings. Nobel active impression coping offered good rotational resistance with all the three impression materials while MIS impression coping had good rotational resistance only in combination with polyether impression materials.

Impression material and coping design play an important role in obtaining rotational resistance for open tray implant level impression. In this study, the rotational resistance recorded for the combination of impression copings and impression materials were above 10 N.Cm except for the combination of MIS impression coping with vinylsiloxanether and vinylpolysiloxane (Group VII and IX). This is above the average and tightening torque levels. Hence, the choice of impression material for an open tray impression is based on the design of the impression coping and the ability of the impression material to resist the rotational tendency of the impression coping within the impression.

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